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FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(Report on Norwegian Fishery and Marine Investigations)
Vol. X. No. 6.
Published by the Director of Fisheries

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Zooplankton Investigations in some Fjords in Western Norway during 1950–1951

by

Kaare R. Gundersen

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A.s John Griegs Boktrykkeri, Bergen

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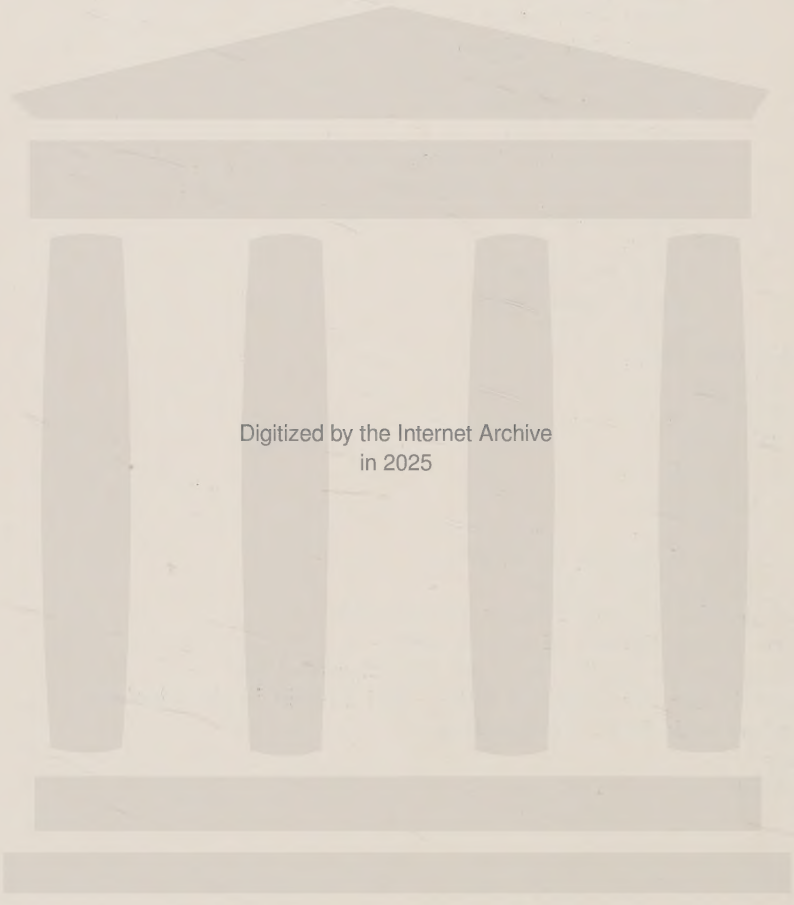

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Preface

The present work was initiated in connection with an investigation of the sprat, *Clupea sprattus* L., at the west coast of Norway. The main purpose was to study the variations in the occurrence of plankton, as the access of food is very important for the quality of the sprat for canning, and the presence of «svartåte« (*Limacina retroversa*) in the stomachs of the sprat causes difficulties in the canning process. The Research Laboratory of the Norwegian Canning Industry, Stavanger has been very interested in this investigation and yielded valuable assistance.

The investigations have mainly been carried out from «Krill» and «Johan Hjort», the vessels of the Institute. To some extent hired vessels have also been used.

I wish to express my sincere thanks to mr. ARTHUR LARSEN at the Research Laboratory of the Norwegian Canning Industry for his valuable help. The chemical analysis have all been carried out by him.

A special thank to Director G. ROLLEFSEN who gave me the opportunity to instal all the necessary equipment on board the «Krill», and to mr. KR. FR. WIBORG who has always been ready to help with the planning and execution of this investigation, and has also revised the manuscript.

Further I wish to thank my colleagues at the Institute and others, who have yielded valuable assistance either by joining the cruises or in other ways.

Bergen, December 1952.

Kaare R. Gundersen.

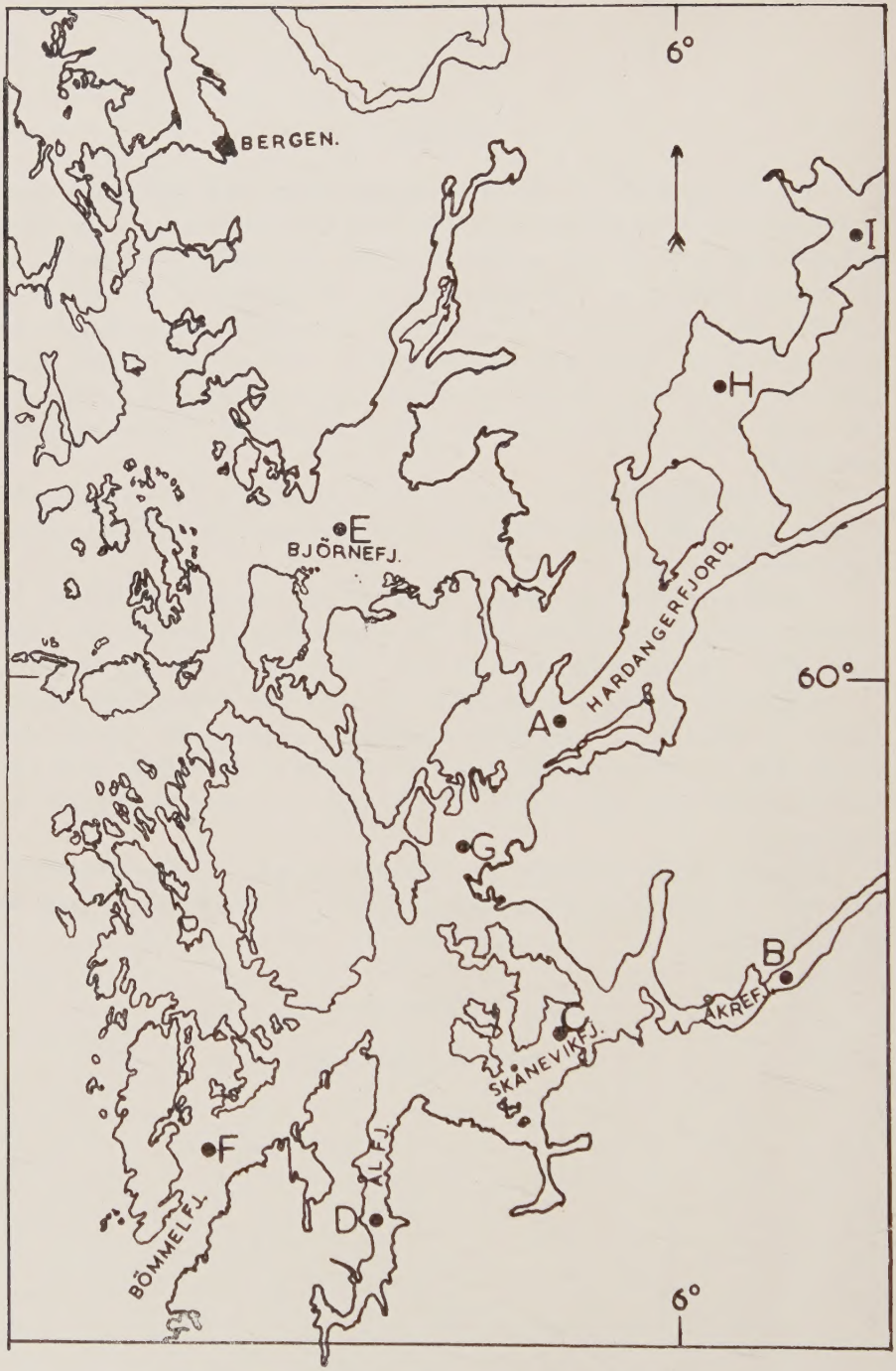

Figure 1. Chart showing Areas. — ● Stations.

Introduction

At the end of February 1950 investigations on zooplankton were initiated by the Directorate of Fisheries, Institute of Marine Research, Bergen, in some fjords south of Bergen on the west coast of Norway, where fishery for sprat, *Clupea sprattus* L. usually takes place during the summer and autumn. The main purpose of the investigations was to study the food conditions for the sprat all the year round, and the possible connection between the fat content of the plankton and of the sprat.

During 1950, five stations (A-E, fig. 1) were worked every fortnight, from the end of February to the middle of December.

The positions of the stations were:

St. A. Hardangerfjord	BN 59° 58' 0	LE 05° 50' 1
St. B. Åkrefjord	BN 59° 46' 0	LE 06° 11' 0
St. C. Skånevikfjord	BN 59° 43' 8	LE 05° 49' 4
St. D. Ålfjord	BN 59° 35' 9	LE 05° 33' 1
St. E. Bjørnefjord	BN 60° 07' 1	LE 05° 32' 2

In 1951 the stations were investigated every month from the beginning of February to the beginning of May, every week from May to September and in this period supplemented with 4 other stations, F—I (Fig. 1).

The positions of these stations were:

St. F. Bømmelfjord	BN 59° 38' 6	LE 05° 18' 2
St. G. Hardangerfjord	BN 59° 52' 1	LE 05° 40' 5
St. H. Hardangerfjord	BN 60° 14' 0	LE 06° 06' 7
St. I. Hardangerfjord	BN 60° 20' 3	LE 06° 17' 5

At all stations vertical hauls were made with a Nansen net «8/72» from 50—0 m., 100—0 m. and 200—0 m. In addition, hauls were also taken at st. C from 270—0 m., at st. s. A, B, E, F, G, H and I from 300—0 m., and finally at st. B from 500—0 m.

In order to get sufficient material for determination of the fat and protein content of the plankton, 4 additional hauls were made at all stations in 1950 from 50—0 m., from the middle of May to the middle of October.

At the st. s A—E temperature observations were made and water samples taken at the usual standard depths for determination of salinity and oxygen every fortnight during both years and handed over to the hydrographical section of the Institute.

The volumes of the plankton samples were measured by displacement. At all stations the 50—0 m. samples were analysed as to the number of individuals and stages of development of the different species present. This was also the case with the samples from 300—0 m. at st. A, and 500—0 m. at st. B.

The content of fat and protein in dry weight of the plankton samples was determined by the Research Laboratory of the Norwegian Canning Industry, Stavanger.

The plankton samples taken during 1951 were measured by volume and given a cursory examination to determine the species present.

In 1949 the Institute initiated investigations of a local herring race in the Lusterfjord, Sogn (Åsen 1952). Plankton samples from 50—0 m. and 300—0 m. were taken in the Lusterfjord every fortnight from the end of 1949 and continued during 1950 and 1951. The volumes of the samples from 1950 and 1951 were measured, and the 50—0 m. samples from 1950 analysed. All the other samples were given only a cursory examination.

Occurence and Variations in Number of the Different Species of Organisms

In order to simplify the analysis of the variations in occurrence and number of the organisms I shall only endeavour to give a description in full detail of the variations at st. A in the Hardangerfjord, and afterwards discuss the deviations found at the other stations.

The Copepods

Of all organisms occurring the copepods were the most important, and have therefore been treated more thoroughly.

1. Calanoida.

Calanus finmarchicus Gunnerus.

Calanus finmarchicus was sparsely present at st. A in the Hardangerfjord in the upper 50 m. from the end of February to the first half of May (table 1).

In the 300—0 m. hauls (table 2) *Cal. fin.* was more numerous. At the end of February the stock was small, mainly consisting of nauplii. In the middle of March the number increased, younger copepodites occuring besides older stages of nauplii and at the end of the month we have a high peak composed mainly of older copepodite stages. Throughout March and April the greater number of *Calanus finmarchicus* kept to the water layers below 50 m. At the end of April the stock had decreased to about 300, mainly adults and older stages of copepodites.

From 10 May to 17 July there is no special difference in the number of *Calanus* in the 50—0 m. and 300—0 m. hauls, the greater part of the stock now living in the upper 50 m. except on 25 May when only 3 specimens occurred in the 50—0 m. hauls while the 300—0 m. haul contained 2 700 individuals, mostly adults and copepodites of stage V.

Throughout June the number of *Cal. fin.* varied between 600 and 700 individuals. At the beginning of July there was a steep increase to the maximum of the year, about 19 600 individuals, mainly copepodites of stage IV, thereafter some decrease, the stock now consisting

Table 1. Number of the different stages of *Calanus finmarchicus* in the 50—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
♂ ..	—	—	—	—	—	1	1	—	5	200	—	—	50	—	—	—	—	—	—
♀ ..	50	—	—	—	—	2	1	50	15	—	100	100	few	—	—	1	—	1	3
V	9	—	few	few	—	13	—	—	100	5500	6750	400	50	7	—	7	50	3	7
IV....	—	—	few	few	few	6	—	—	550	12000	6250	200	50	12	100	2	—	50	7
III ..	—	—	—	100	—	—	—	100	—	2000	100	—	50	50	100	—	—	—	1
II	—	—	—	—	—	100	—	150	—	—	—	—	50	—	—	—	—	—	1
I	—	—	—	—	—	300	1	100	—	—	—	—	—	—	100	—	—	—	—
N	9	200	—	—	—	1300	—	100	—	—	—	—	—	—	400	—	—	—	—
Total	68	200	—	100	—	1722	3	500	670	19700	13200	700	250	69	700	10	50	54	19

Table 2. Number of the different stages of *Calanus finmarchicus* in the 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/11
♂ ..	3	—	—	200	6	—	103	50	10	250	12	few	few	—	few	—	—	few	—
♀ ..	42	4	—	10	4	50	1500	150	2	250	500	250	50	—	—	250	—	—	—
V	25	1	50	50	—	200	1100	200	350	5250	7250	1750	1450	250	750	1000	1050	1500	1700
IV....	1	—	400	50	150	—	—	—	250	11500	3500	1000	950	1000	—	250	350	500	550
III ..	—	—	400	100	50	50	—	—	—	2250	—	—	100	—	—	—	—	—	110
II	—	200	450	—	—	300	—	150	—	—	—	—	—	250	—	—	—	—	—
I	9	200	350	—	100	600	—	150	—	—	—	—	—	—	—	—	—	—	—
N	250	250	600	—	—	1100	—	100	—	—	—	—	—	—	—	—	—	—	—
Total	330	655	2250	410	310	2300	2703	700	612	19500	11262	3000	2250	1500	750	1500	1400	2000	2350

mainly of stage V. During July nearly all the *Cal. fin.* were taken in the upper 50 m., but in August the stock gradually moved to deeper layers, and later the entire stock resorted to the layers below 50 m., (table 1 and 2), except in the last half of September when both hauls yielded the same number of *Cal. fin.*

Nauplii were numerous in February and March, occurring mainly below 50 m., in May — June and September above 50 m. *Cal. fin.* accordingly has 3 spawning periods in the Hardangerfjord at st. A., the most important one in May—June.

At st. B. in the Åkrefjord (table 3) *Calanus finmarchicus* was more numerous than at st. A in the Hardangerfjord in the upper 50 m. from February to the end of June, except in the middle of May. Spawning took place in February—March and May only, and the nauplii were not so numerous as at st. A. At the beginning of July on the other hand the stock was insignificant and remained small.

In the deeper water layers (table 4) the number of *Cal. fin.* increased considerable from July to a maximum in August, but decreased gradually from September to December.

At the other localities investigated the hauls from 50—0 m. only have been analysed and accordingly have to be compared with the corresponding hauls at st. A in the Hardangerfjord.

At st. C in the Skånevikfjord (table 5) the stock of *Cal. fin.* was quite considerable from February to the beginning of July. The nauplii numbered 2 700 at the end of March but were lacking in May. We have the same increase of the stock in July as at st. A, but occurring a little later, reaching a maximum of 11 300 on 18 July, and in August there were still more than 3 000 individuals. From August to December the variations were largely as at st. A.

At st. D in the Ålfjord the numbers were also quite large from February to the middle of May with a maximum of nauplii in the middle of March (table 6). From June to December the stock was generally smaller than at st. A, especially in July.

At st. E in the Bjørnefjord the number of *Cal. fin.* nauplii was higher in the middle and at the end of March than at st. A (table 7), and the stock of copepodites was also larger from the middle of March to the middle of June. We find a heavy increase in the total stock in July, the maximum occurring on July 17, a little later than at st. A, the figures also being considerably lower. From the beginning of August to December the stock variations were as at st. A.

In the Lusterfjord (table 8) *Calanus finmarchicus* was much more scarce than in the fjords mentioned above. The numbers were highest from May to July, reaching a maximum of 700 individuals on 15 June.

Table 3. Number of the different stages of *Calanus finmarchicus* in the 50—0 m. hauls at st. B. in the Åkrefjord February—December 1950.

1950	24/2	15/3	29/3	14/4	27/4	11/5	24/5	7/6	21/6	6/7	18/7	3/8	16/8	30/8	22/9	4/10	25/10	8/11	24/11	15/12
♂	—	2	—	50	—	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—
♀	—	8	—	50	—	—	—	—	—	—	few	—	6	20	2	—	—	—	—	—
V	—	—	—	50	—	few	—	50	250	200	100	36	150	45	10	—	1	—	—	5
IV	—	—	100	—	—	—	—	100	150	100	—	5	—	—	5	4	—	1	1	5
III	—	—	100	200	—	—	—	—	200	—	—	—	—	50	—	1	—	1	1	4
II	—	—	50	100	50	50	100	—	50	—	—	—	—	—	—	—	—	—	—	—
I	9	50	—	—	—	—	200	—	—	—	—	—	—	—	—	—	—	—	100	—
N	291	50	—	—	—	400	100	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	300	110	250	450	50	450	400	150	650	300	100	41	156	121	17	5	1	2	102	14

Table 4. Number of the different stages of *Calanus finmarchicus* in the 500—0 m. hauls at st. B in the Åkrefjord February—December 1950.

1950	24/2	15/3	29/3	14/4	27/4	11/5	24/5	7/6	21/6	6/7	18/7	3/8	16/8	30/8	22/9	4/10	8/11	24/11	15/12
♂ ..	16	—	—	100	—	—	—	—	—	few	250	—	—	—	—	—	—	—	—
♀ ..	16	few	—	few	—	—	—	—	250	—	—	—	—	—	—	—	—	—	—
V	9	—	150	150	50	few	—	500	500	750	750	2250	1500	1500	750	1250	300	600	350
IV....	—	—	500	—	50	—	100	250	—	250	—	—	500	750	50	—	50	200	150
III ..	—	—	650	—	150	—	—	—	—	—	—	—	—	—	—	—	—	—	—
II	—	200	400	—	—	—	—	—	—	—	—	—	500	—	—	—	—	—	—
I	—	400	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N	350	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	391	700	1750	250	250	—	100	750	750	1000	1000	2250	2500	2250	800	1250	350	800	500

Table 5. Number of the different stages of *Calanus finmarchicus* in the 50—0 m. hauls at st. C in the Skånevikfjord February—December 1950.

1950	23/2	15/3	29/3	14/4	27/4	11/5	24/5	8/6	21/6	7/7	18/7	2/8	17/8	31/8	21/9	5/10	25/10	8/11	24/11	14/12
♂	—	—	—	—	50	50	—	—	50	250	150	50	—	—	1	—	—	—	—	—
♀	42	—	—	—	50	900	—	few	—	350	550	150	—	—	—	—	—	—	—	—
V	—	—	—	50	—	2650	200	—	300	1200	6050	2350	90	7	5	50	5	1	4	1
IV	—	—	few	—	150	550	—	450	1950	1250	4350	850	23	—	6	—	—	1	5	7
III	—	—	100	400	50	—	50	450	850	400	200	50	50	—	—	—	—	—	—	8
II	—	50	300	100	—	—	—	50	50	—	—	—	100	—	—	—	—	—	—	—
I	—	200	300	0	100	—	100	—	100	—	—	—	—	—	—	—	—	—	—	—
N	209	700	2700	200	—	—	—	—	—	—	—	—	—	50	—	—	—	—	—	—
Total	251	950	3400	750	400	4150	350	950	3300	3450	11300	3450	263	57	12	50	5	2	9	16

Table 6. Number of the different stages of *Calanus finmarchicus* in the 50– 0 m. hauls at st. D in the Ålfjord February—December 1950.

1950	23/2	15/3	28/3	14/4	26/4	10/5	25/5	8/6	22/6	7/7	19/7	4/8	18/8	1/9	21/9	26/10	9/11	24/11	14/12
♂ ..	3	—	—	—	50	50	—	—	—	few	200	7	—	2	—	—	—	—	—
♀ ..	125	—	50	100	50	150	—	—	200	few	100	50	3	8	3	—	—	1	—
V	9	50	—	650	1100	150	—	200	100	500	1900	—	15	19	9	—	1	13	1
IV....	—	100	100	950	550	—	—	50	450	250	1500	—	1	19	3	—	1	7	4
III ..	—	300	600	1350	50	200	—	150	250	100	100	—	1	few	—	—	—	—	1
II	—	—	750	400	—	200	—	150	—	—	—	—	—	few	—	—	—	—	—
I	—	400	400	100	—	200	—	—	—	—	—	—	—	50	—	—	—	50	—
N	—	4000	2700	—	100	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	137	4850	4600	3550	1900	950	—	550	1000	850	3800	57	20	98	15	—	2	71	6

Table 7. Number of the different stages of *Calanus finmarchicus* in the 50—0 m. hauls at st. E in the Bjørnefjord February—December 1950.

1950	25/2	17/3	30/3	15/4	28/4	9/5	26/5	9/6	23/6	6/7	17/7	2/8	19/8	29/8	20/9	27/10	7/11	23/11	16/12
♂ ..	—	—	—	100	—	100	50	50	3	few	50	few	—	—	—	—	—	—	—
♀ ..	42	7	few	few	50	850	200	200	16	50	300	50	3	—	3	1	—	1	—
V	1	—	—	50	450	550	50	200	100	250	5500	550	20	1	9	1	6	10	7
IV....	16	—	400	200	100	50	300	1050	200	750	5350	550	7	4	3	—	4	7	20
III ..	9	50	400	750	—	50	200	500	500	50	500	—	—	2	2	—	1	50	2
II	9	—	400	—	—	—	200	50	—	50	—	—	—	—	—	—	—	—	—
I	—	100	300	—	200	100	350	—	—	50	—	—	—	—	—	—	—	—	—
N	—	1000	700	—	200	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	77	1157	2200	1100	1000	1700	1350	2050	819	1200	11700	1150	30	7	17	2	11	68	29

Table 8. Number of the different stages of *Calanus finmarchicus* in the 50—0 m. hauls in the Lusterfjord January—November 1950.

1950	16/1	4/2	14/2	1/3	14/3	3/4	13/4	2/5	13/5	2/6	15/6	3/7	14/7	1/8	14/8	1/9	15/9	2/10	14/10	1/11	14/11
♂	—	—	—	—	—	1	1	few	—	50	few	50	100	1	—	—	—	—	—	—	—
♀	—	—	—	—	—	1	3	few	few	50	300	150	300	2	few	—	1	3	1	4	—
V	3	1	5	—	—	13	40	150	—	100	400	50	50	—	few	3	2	5	1	1	15
IV	few	—	—	1	—	20	100	150	150	—	—	—	—	—	—	1	—	4	3	—	3
III	few	—	—	—	—	100	50	200	50	—	—	—	—	—	—	—	—	4	—	—	—
II	—	—	—	—	—	50	—	—	—	—	—	—	—	—	100	—	—	—	—	—	—
I	—	—	—	—	—	—	—	100	—	—	—	—	—	—	—	—	—	—	—	—	—
N	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	3	1	5	1	—	185	194	600	200	200	700	250	450	3	100	4	3	16	5	5	20

Calanus hyperboreus KRÖYER.

At st. A in the Hardangerfjord some nauplii of *Calanus hyperboreus* were taken in the upper 50 m. at the end of February. In the 300—0 m. hauls some females and older copepodites were found from the middle of March to the beginning of August and from the end of October to the middle of December. The stock was small all the time, with one peak in March and one in November, 155 and 157 individuals respectively.

In the Åkrefjord *Calanus hyperboreus* occurred sporadically in the 50—0 m. hauls. In the 500—0 m. hauls it was always present but in small numbers, 1—27 individuals.

I the Skånevikfjord, the Ålfjord and the Bjørnefjord *Calanus hyperboreus* was always scarce in the upper 50 metres, and in the Lusterfjord not present at all.

Pseudocalanus minutus KRÖYER.

At the end of February the stock of *Pseudocalanus minutus* at st. A in the Hardangerfjord consisted of about 1 000 individuals in the upper 50 m., including adults, copepodites and nauplii (table 9). In the middle of March the number decreased considerably, only a hundred nauplii now being found.

During April, May and June the stock was small.

At the beginning of July there was a vigorous increase to about 10 000 specimens. The presence of nauplii and females with egg-sacs showed that spawning had taken place and was still going on. The stock decreased considerably at the beginning of August. In the middle of the month the number again rose to a high number, 7 300 individuals, and nauplii were still present. Later the stock decreased gradually, and from the end of September the number was quite insignificant in the upper layers, but below 50 m. a moderate stock still existed at the end of October (table 10). *Pseudocalanus minutus* disappeared entirely from the 50—0 m. layer after November 7.

From the end of February to the end of August the greater part of the stock occurred in the upper 50 m. from September to December mainly below 50 m.

At st. B in the Åkrefjord (table 11—12) the stock of *Pseudocalanus minutus* was generally a little higher as at st. A from February until the end of May. During the remainder of the year the number was smaller. During most of the year the greater part of the stock kept to the upper layer.

Table 9. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls at st. A in the Hardangerfjord February—November 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11
Adults	200	—	—	50	—	100	—	—	100	3700	2200	650	1300	300	—	—	150
Copepodites & nauplii	800	100	—	200	200	1200	200	—	—	6600	5900	2350	6000	1100	300	—	200
Total	100	100	—	250	200	1300	200	—	100	10300	8100	3000	7300	1400	300	—	350

Table 10. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
Adults	550	—	100	50	—	150	—	—	—	4250	4000	1250	1050	500	—	500	150	100	200
Copepodites & nauplii	1750	—	200	100	400	500	500	—	300	5500	7750	6750	6800	3000	1500	2500	250	400	350
Total ..	2300	—	300	150	400	650	500	—	300	9750	11750	8000	7850	3500	1500	3000	400	500	550

Table 11. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls at st. B in the Åkrefjord February—November 1950.

1950	24/2	15/3	29/3	14/4	27/4	11/5	24/5	7/6	21/6	6/7	18/7	3/8	16/8	30/8	22/9	4/10	25/10	8/11
Adults	3	—	50	200	—	100	200	—	50	—	50	100	200	100	—	—	—	—
Copepodites & nauplii	118	550	800	300	100	3500	700	50	150	—	100	500	600	750	200	300	30	100
Total	121	550	850	500	100	3600	900	50	200	—	150	600	800	850	200	300	30	100

Table 12. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 500—0 m. hauls at st. B in the Åkrefjord February—December 1950.

1950	24/2	15/3	29/3	14/4	27/4	11/5	24/5	7/6	21/6	6/7	18/7	3/8	16/8	30/8	22/9	4/10	8/11	24/11	15/12
Adults	9	—	50	150	—	—	200	250	—	—	—	—	—	250	—	—	—	—	50
Copepodites & nauplii	459	600	800	—	500	2000	200	—	—	1000	1000	—	1000	—	—	—	200	—	—
Total	468	600	850	150	500	2000	400	250	—	1000	1000	—	1000	250	—	—	200	—	50

At st. C in the Skånevikfjord (table 13) the stock of *Pseudocalanus minutus* was quite equal to that of the Hardangerfjord except in the middle of July when it was a little below.

At. st. D in the Ålfjord (table 14) *P. m.* were very numerous from the end of February to the middle of May and the maximum in the middle of July was about twice the size of the July maximum at st. A, but from the beginning of August and onwards the stock was below that of st. A.

At st. E. in the Bjørnefjord (table 15) the numbers of *P. m.* exceeded those at st. A all the time and were also high in the latter part of May and at the end of September.

The Lusterfjord (table 16) had a small stock of *P. m.* compared with that of the other fjords, with a maximum of 2 500 individuals at the beginning of June.

Microcalanus pygmæus G. O. Sars.

Microcalanus pygmæus occurred in moderate numbers in the upper 50 m. at st. A (table 17). From February to July the stock numbered 500—1900 individuals with maximum in the middle of April. Later the number varied irregularly.

In the 300—0 m. hauls a somewhat larger number of *M. p.* was found. There was a peak of 6 000 individuals in May and another peak of 5 500 individuals at the end of September.

In the other fjords *M. p.* had approximately the same occurrence in the upper 50—0 m. as at st. A. *Microcalanus* was lacking at most of the stations in the middle of July and middle of August.

In the 300—0 m. hauls at st. *A Microcalanus pygmæus* was present most of the year. Females were more numerous than males. The males were irregular in their appearance, absent on March 30, May 25 and June 8, during July—August and in November.

Pareuchaeta norvegica Boeck.

Copepodites and nauplii of *Pareuchaeta norvegica* occurred sparsely at st. A in the upper 50 m., varying from 0—51 individuals in the course of the year.

In the 300—0 m. hauls the total number varied from 7—265. Copepodites were always present, younger copepodites from the end of February to the middle of April and in November, stage IV—V from April to November. Females occurred at the end of March, in the middle of May, in June—August and from September to November,

Table 13. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls at st. C in the Skånevikfjord February—December 1950.

1950	23/2	15/3	29/3	14/4	27/4	11/5	24/5	8/6	21/6	7/7	18/7	2/8	17/8	31/8	21/9	5/10	25/10	8/11	24/11	14/12
Adults	116	—	—	—	50	—	100	150	50	1500	2400	1000	600	300	50	100	50	—	—	100
Copepodites & nauplii	850	50	550	—	600	300	2000	100	500	—	3800	1500	6700	950	1600	100	50	—	—	100
Total	966	50	550	—	650	300	2100	250	550	1500	6200	2500	7300	1250	1650	200	100	—	—	200

Table 14. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls at st. D in the Ålfjord February—December 1950.

1950	23/2	15/3	28/3	14/4	26/4	10/5	25/5	8/6	22/6	7/7	19/7	4/8	18/8	1/9	21/9	26/10	9/11	24/11	14/12
Adults ..	750	150	100	300	150	200	100	50	100	400	17300	—	—	250	50	5	—	50	40
Copepodites & nauplii	1650	1300	2350	800	2900	1400	50	350	—	850	4600	1300	650	250	1000	—	—	—	50
Total ..	2400	1450	2450	1100	3050	1600	150	400	100	1250	21900	1300	650	500	1050	5	—	50	90

Table 15. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls at st. E in the Bjørnefjord February—December 1950.

1950	25/2	17/3	30/3	14/4	28/4	9/5	26/5	9/6	23/6	6/7	17/7	2/8	19/8	29/8	20/9	27/10	7/11	23/11	16/12
Adults ..	124	—	—	50	200	100	100	—	900	2850	6300	1600	500	100	700	300	—	50	100
Copepodites & nauplii	1359	100	800	1050	600	2700	5800	200	450	5300	8700	11300	5000	300	8600	200	—	—	150
Total ..	1483	100	800	1100	800	2800	5900	200	1350	8150	15000	13900	5500	400	9300	500	—	50	250

Table 16. Number of adults, copepodites & nauplii of *Pseudocalanus minutus* in the 50—0 m. hauls in the Lusterfjord January—November 1950.

1950	16/1	4/2	14/2	1/3	14/3	3/4	13/4	2/5	13/5	2/6	15/6	3/7	14/7	1/8	14/8	1/9	15/9	2/10	14/10	1/11	14/11
Adults ..	—	—	—	—	50	—	50	300	350	600	450	650	250	—	—	—	—	—	10	10	—
Copepodites & nauplii ..	100	—	—	—	50	—	—	250	100	1900	400	150	50	50	150	200	5	—	15	—	10
Total	100	—	—	—	100	—	50	550	450	2500	850	800	300	50	150	200	5	—	25	10	10

Table 17. Total number of *Microcalanus pygmæus* in the 50 – 0 m. and 300– 0 m. hauls at st. A, in the 50 – 0 m. and 500—0 m. hauls at st. B, and in the 50—0 m. hauls at the st. s C, D and E. February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
St. A 50 m.	1350	1600	—	1900	1000	700	500	1400	700	1000	—	300	—	400	—	—	500	1000	750
St. A 300 m.	2200	2650	1200	3600	3300	4900	6000	1400	1100	2500	—	2000	1100	4500	5500	1750	700	1200	1800
St. B 50 m.	108	700	1700	2200	1100	300	—	—	400	—	—	—	—	—	—	830	100	400	2800
St. B 500 m.	550	2100	2100	3000	5800	5500	6400	2500	2000	1000	—	1000	—	2000	900	1500	2800	3600	4900
St. C 50 m.	400	—	200	1200	2100	—	300	600	700	—	—	—	—	250	—	150	200	700	250
St. D 50 m.	350	100	300	800	1100	100	—	100	—	—	—	—	—	—	—	—	50	250	380
St. E 50 m.	91	650	300	1100	500	900	700	500	200	650	800	700	—	—	—	—	—	100	800

Table 18. Number of adults, copepodites & nauplii of *Temora longicornis* in the 50—0 m. and 300—0 m. hauls at st. A in the Hardangerfjord February—September 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9
50—0 m.															
Adults	—	—	—	—	—	—	—	—	500	1700	700	—	—	—	100
Copepodites & nauplii	150	—	—	100	300	1500	1300	700	1150	5500	1300	50	500	—	300
Total	150	—	—	100	300	1500	1300	700	1650	7200	2000	50	500	—	400
300—0 m.															
Adults	—	—	50	—	1	—	—	150	700	4750	1750	—	—	—	—
Copepodites & nauplii	100	50	50	100	900	1700	2500	200	1200	6000	—	—	100	—	—
Total	100	50	100	100	901	1700	2500	350	1900	10750	1750	—	100	—	—

with egg-sacs and attached spermatophores in the middle of August at the end of October and in the last days of November.

In the other fjords *Pareuchaeta norvegica* was always scarce in the upper water layers.

Temora longicornis O. F. Müller.

Copepodites and nauplii of *Temora longicornis* occurred very sparsely at st. A from February to the middle of April (table 18). From the middle of June adults were also present. The stock increased to a maximum on July 5, but decreased sharply a fortnight later and was quite small the rest of the year, varying from 0—500 individuals. The variation was nearly identical in the 50—0 m. and 300—0 m. hauls' indicating that *Temora* frequents to the upper 50 m.

In the Åkrefjord *Temora* had a maximum in the middle of May of 8 800 individuals, there was also a peak in the middle of July but not so high as in the Hardangerfjord.

In the Skånevikfjord *Temora* was present from February to the middle of August, but the stock was smaller than in the Hardangerfjord, the maximum, 3 000 specimens, on June 21.

In the Ålfjord the stock was also smaller than at st. A with a maximum of 2 500 individuals on July 19.

In the Bjørnefjord the maximum (2 000 individuals) occurred in the beginning of May. At other times the numbers were below those of the Hardangerfjord.

In the Lusterfjord *Temora* was very numerous at the beginning of June, (maximum 12 400 individuals), at other times the stock did not differ essentially from that of Hardangerfjord.

Metridia longa Lubboch and *M. lucens* Boeck.

Metridia longa and *M. lucens* have been taken together, table 19. At st. A they were found sparsely in the 50—0 m. hauls all the time, the numbers varying from 0—600, mainly copepodites and nauplii. In the deep hauls all stages occurred in greater numbers. Maximum numbers were found from the middle of May to the beginning of June, minimum numbers occurred in July. Nauplii were present for a longer period in the deeper hauls, from February to the beginning of June.

From the occurrence of nauplii it is apparent that spawning takes place twice in the year, from the last half of February to the middle of May and from the end of October to the middle of December. In the first period adults and copepodites of both *M. longa* and *M. lucens* occurred, but because of the much higher number of *M. longa* we may assume that the nauplii mainly belong to this species. In the last

Table 19. Number of adults, copepodites and nauplii of *Metridia* spp. in the 50—0 m. and 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
50—0 m.																			
Adults	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	few	—	11	—
Copepodites	—	50	—	250	—	5	301	100	50	—	200	—	—	—	100	200	300	100	50
Nauplii	500	300	—	250	—	—	—	—	—	—	—	—	—	—	—	400	100	—	150
Total	501	400	—	500	—	5	301	100	50	—	200	—	—	1	100	600	400	111	200
300—0 m.																			
Adults	9	68	21	50	33	107	—	50	50	—	—	—	150	250	—	—	—	50	—
Copepodites	18	—	500	550	650	1550	900	1150	900	few	few	few	350	750	250	750	400	200	400
Nauplii	350	550	400	500	200	800	500	200	—	—	—	500	—	—	—	—	100	—	200
Total	377	618	921	1100	883	2457	1400	1400	950	few	few	500	500	1000	250	750	500	250	600

Table 20. Total number of *Acartia clausi* and *A. longiremis* in the 50—0 m. and 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
50—0 m.	150	—	—	—	400	600	300	250	2100	7000	1500	600	700	600	11300	350	350	800	400
300—0 m.	150	100	—	100	200	1100	1000	300	3750	7000	1500	500	450	500	8000	1000	300	400	300

period only adults of *M. lucens* were present, probably having its main spawning at this time of the year.

In the Åkrefjord the stock of *Metridia* spp. was quite considerable from February to the beginning of July, with a large number of nauplii in March—April, (varying from 6 700—2 700). From July and during the rest of the period investigated the size of the stock was approximately as at st. A.

In the Bjørnefjord and the Skånevikfjord the *Metridia* spp. were more numerous than in the Hardangerfjord but in the Ålfjord more equal to that of st. A.

The Lusterfjord had a small stock of *Metridia* spp. all the year.

Acartia clausi Giesbrecht and *A. longiremis* Lilljeborg.

Acartia clausi and *A. longiremis* have also been taken together in one group, but *Acartia clausi* was dominant during the entire period. They were sparsely represented in the Hardangerfjord from February to the end of May (table 20). In the course of June the stock increased and was rather numerous at the beginning of July. In August the number decreased, but rose to maximum in September. Later the numbers again fell off, varying from 355—800 till December. Nauplii were present at the end of April, in the middle of May, at the end of June, beginning of August and finally at the end of September. Propagation thus takes place during a longer period. Males were found in August only, while females were present in February, May—August and October—November.

As the *Acartia* spp. mainly frequent the upper 50 m., the 300—0 m. hauls did not differ very much from the 50—0 m. hauls as to number.

In the Åkrefjord and the Ålfjord the maximum number occurred about the middle of July, a fortnight later than in the Hardangerfjord, but no second peak was observed in September. In the Bjørnefjord and the Skånevikfjord the stocks did not increase in July and September.

In the Lusterfjord the *Acartia* spp. (*clausi*) varied in number as in the other fjords, but the maximum occurred at the beginning of June, and there was no increase in September.

Other Calanoids.

The following species of *Calanoids* have been taken more or less accidentally and in small numbers.

Paracalanus parvus Claus (table 21). Apart from a few specimens in February, this species did not appear in the Hardangerfjord until the beginning of July. In the last part of September we have the maximum, 15 000 individuals. Later the number decreased to a minimum

Table 21. Total number of *Paracalanus parvus* in the 50—0 m. and 300—0 m. hauls in the Hardangerfjord February—December 1950.

1950	24/2	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
50—0 m.	350	—	—	—	2000	1500	15000	1300	200	800	2700
300—0 m.	200	500	500	1500	2600	9500	23500	1750	1000	100	950

Table 22. Total number of *Chiridius armatus* in the 300—0 m. hauls in the Hardangerfjord and in the 500—0 m. hauls in the Åkrefjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
St. A.																			
300—0 m.	25	152	113	23	10	100	4	6	5	2	11	4	2	7	19	8	12	18	22
St. B.																			
500—0 m.	185	12	14	45	66	66	400	40	38	21	8	17	5	5	6	2	6	4	13

Table 23. Total number of *Oithona helgolandica* in the 50—0 m. and 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	24/2	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	8/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
50—0 m.	1300	2350	50	4000	1700	2900	2500	1850	2900	4000	6400	4300	5400	2500	7300	1700	2000	1100	1850
300—0 m.	2000	1950	1400	2100	1900	6300	7500	1300	3200	7500	8000	2500	5800	6000	7500	7250	5100	2900	1950

at the end of November but rose again in December. From July to the beginning of August *Paracalanus* was not taken in the upper 50 m. and the stock was always greater in the 300—0 m. hauls except in February and in November—December.

In the other fjords the variations were similar.

Spinocalanus abyssalis Giesbrecht was never taken in the 50—0 m. hauls, but nearly always present in the deeper hauls. In the Hardangerfjord maximum occurred at the end of August, (4 000 individuals). At other times the stock was comparatively small, varying between 50—500 individuals. In Åkrefjord there was no distinct maximum.

Æetideus armatus Boeck was also sparsely present in August and September. It occurred more frequently in the 300—0 m. hauls numbering from 0—250 specimens.

Chiridius armatus Boeck was found sparsely (2—400 individuals) in all the fjords, mainly below 50 m., Maximum numbers in February —March and in May (table 22).

Amallophora magna Scott, a few specimens in February—March, May—June and November—December. Only found in the deep hauls in the Hardangerfjord and the Åkrefjord.

Scolecithricella minor Brady. Single individuals were found in February, June, November and December, mainly above 50 m.

Centropages typicus Kröyer was never numerous but occurred continuously from June to September, the stock varying from 50—1 600 specimens, single individuals also being found in March and December.

Heterorhabdus norvegicus Boeck, single specimens at the beginning of August and in November, *Candacia norvegica* Boeck in October and December and *Paroithona parvula* Farran in November and December. Only found in the deep hauls at st. A and st. B.

2. Cyclopoida.

Oithona helgolandica Claus.

Oithona helgolandica was present in the Hardangerfjord during the whole period investigated with a spring maximum in April, and a rich stock of 4 000—7 500 individuals from the beginning of July to the last part of September, (table 23). In May, October and November the number was considerable higher in the 300—0 m. hauls than in the upper 50 m.

In the Åkrefjord a great increase took place in the course of May, the stock of *Oithona* reaching about 28 300 individuals, the highest number found at all the stations investigated. After May the number varied between 500 and 3 000.

From February to the last part of May the stock frequented the upper water layers, but from the beginning of June kept mainly below 50 m.

In the other fjords *O. h.* varied in numbers approximately as in the Hardangerfjord.

Oithona spinirostris CLAUS.

Oithona spinirostris CLAUS appeared in the Hardangerfjord now and then and never in great numbers, with peaks in the middle of May and at the end of August, 1 300 and 1 500 individuals respectively. *O. s.* was mainly taken below 50 m.

In the Åkrefjord and the Bjørnefjord the conditions were similar, but in the other fjords *O. s.* occurred more sparsely.

Oncaea borealis G. O. SARS.

Oncaea borealis G. O. SARS was taken in small numbers, 300—100 individuals in the upper 50 m. in all the fjords from the middle of April to the beginning of July. Then it dissappeared from the surface layers and did not occur until November—December. In the 300—0 m. hauls *O. b.* was present all the time investigated and in higher numbers, maximum in May, 5 500 individuals.

Other Organisms

Cladocera.

The numerical variations of the Cladocera, *Evadne nordmanni* LOVÉN and *Podon* spp. are shown in table 24. In the Hardangerfjord *Evadne* appeared in the upper 50 m. in moderate number at the end of April, and *Podon* spp. in the last part of May. Maximum number of *Evadne* occurred in the middle of May and of *Podon* in the middle of July in the upper 50 m.

At the end of August, the greater part of the Cladocera apparently kept below 50 m., as the numbers then were higher in the deep hauls.

In the Åkrefjord, the Bjørnefjord and the Ålfjord the Cladocera were less numerous, and present for a shorter period, while the conditions in the other fjords were more similar to those of the Hardangerfjord.

Euphausiacea.

Adults of Euphausiids occurred seldom. A few specimens of *Meganyctiphanes norvegica* M. SARS were caught in September, October and November. Eggs, nauplii and metanauplii were more frequent but not numerous. The numbers varied between 1—100 from the

Table 24. Total number of *Evadne nordmanni* and *Podon* spp. in the 50—0 m. and 300—0 m. hauls at st. A in the Hardangerfjord February—December 1950.

1950	17/3	30/3	15/4	28/4	10/5	25/5	8/6	22/6	5/7	17/7	1/8	16/8	30/8	20/9	26/10	7/11	24/11	15/12
50—0 m.																		
Evadne	—	—	—	300	2100	900	1650	1800	300	100	—	—	300	300	—	100	700	550
Podon sp.	—	—	—	—	—	100	250	600	1800	2800	200	1500	1300	1200	—	—	100	—
300—0 m.																		
Evadne	50	—	100	300	2100	500	1200	2000	500	—	—	—	1750	500	—	400	300	350
Podon sp.	—	—	—	—	—	—	700	800	3000	1000	250	1000	4750	—	—	100	—	—

last half of February to the end of June. The calyptopis and furcilia stages were present from June to the beginning of August, the number varying from 1—213. Similar conditions were found in the other fjords. The Euphausiid larvae occurred mainly in the upper 50 m.

Decapoda.

Decapod larvae appeared in the upper 50—0 m. in all the fjords at the beginning of May, and were present continuously from the beginning of June to the middle of August, in the deeper hauls numbers were low, from the middle of March 1—36 specimens. In the Lusterfjord Decapod larvae only occurred singly.

One specimen of *Pasiphaea tarda* KROYER was caught in the Hardangerfjord and one in the Åkrefjord at the beginning of June and some specimens of *P. sivado* RISSO in the Hardangerfjord in May and August, all in the deeper hauls.

Gastropoda.

Limacina retroversa FLEMM appeared suddenly in the Hardangerfjord at the beginning of July in quite large numbers (1 100), and a fortnight later the stock had increased to a maximum of 5 700 individuals. As mentioned above we had at the same time a great increase in the stock of *Calanus finmarchicus* and of *Pseudocalanus minutus*. At the end of August *Limacina retroversa* was still numerous but had disappeared a fortnight later. A few young individuals were found in the last part of September.

In the Åkrefjord *Limacina retroversa* did not occur until the middle of July, and then in very small numbers only. In the Bjørnefjord, the Skånevikfjord and the Ålfjord it appeared in the middle of July a fortnight later than in the Hardangerfjord, 2 550, 8 500 and 10 600 individuals respectively.

Chaetognatha.

Chaetognatha were sparsely present in the upper 50 m. of the Hardangerfjord in February, March, at the beginning of June and in the middle of July. From the middle of August to December they were found continuously but in small numbers, 1—24 individuals. In the deeper hauls the Chaetognatha were alvays present, varying between 4—55 specimens, the highest numbers occurring from the middle of July to December.

Copelata.

The Appendicularians *Oikopleura* spp. and *Fritillaria borealis* LOHM, have been lumped. They occurred in varying quantity all the time

mainly in the upper 50 m. and reached maximum at the beginning of July (2 700 individuals) in the Hardangerfjord.

Larvae of Bottom Invertebrates

Larvae of bottom invertebrates were sparsely present in all the fjords in February and March. From the middle of April the number increased and reached a maximum of 4 300 specimens in the first half of May. The number later varied irregularly between 500—2 000, but on the whole decreased after the middle of July, and the larvae disappeared in the middle of August. A few larvae of Polychaeta were found in the last part of September. The major part of the larvae kept to the 50—0 m. layer.

In the Ålfjord bottom invertebrate larvae were scarce all the time.

Fish Eggs and Larvae

Fish eggs were found sparsely in the 50—0 m. hauls in most of the fjords from the end of April to the middle of July, a few also in the middle of March. The number was not high, varying from 0—26. In the deeper hauls eggs were found from February to the middle of October. Eggs of the following species were identified: *Argentina silus, Pleuronectes flesus, Scomber scomber, Clupea sprattus, Callionymus lyra, Mychtophum glaciale,* and of the following genera: Gadidae and Pleuronectidae.

Fish larvae were most frequent in the upper water layers from the beginning of June to the middle of July, varying between 0—13. Some larvae occurred also in the middle of April and the middle of August.

The following species were represented: *Clupea harengus, Clupea sprattus, Gadus morrhua, G. luscus, G. poutassou, G. merlangus, Molva dipterygia, Labrus berggylta, Ctenolabrus rupestris, Lepidorhombus wiffjagonis, Pleuronectes microcephalus, Scomber scomber, Sebastes marinus viviparus* and *Gobius flavescens* and not determined species of Gobidae and Gadidae.

In the Bjornefjord fish larvae were not found in the upper 50 m.

The Composition of the Plankton during 1951

As mentioned above the plankton samples from 1951 were not analysed as to the number of individuals but were given only a cursory inspection. All species occurring were noticed and their relative abundance estimated roughly. The examination showed that mainly the

same species occurred both years and in nearly the same proportions, but some differences were found. At st. A in the Hardangerfjord *Calanus finmarchicus* was much more abundant in the middle of April 1951 than in April the year before. Both years *C. f.* dominated the plankton entirely in the first half of July, but while the greater part of the stock in 1950 was taken in the upper 50 m., *C. f.* in the middle of July 1951 had already migrated below the 50 m. level.

From April to the middle of July *Calanus finmarchicus* seems to be more numerous in the Åkrefjord in 1951 than in 1950.

Metridia spp. occurred in the deeper layers mainly in the same numbers both years, but was very plentiful in the upper 50 m. in the Åkrefjord in May—June 1951 while it in 1950 was sparsely present.

Limacina retroversa occurred in great numbers during July 1950 at most of the stations but was scarce in 1951.

In the Lusterfjord *Calanus finmarchicus* was never present in notable numbers in the 50—0 m. hauls in 1951, while in 1950 a maximum in the volume of plankton in June was mainly caused by *Calanus finmarchicus*. (See below). During September 1951 *Pseudocalanus minutus*, *Temora longicornis*, *Acartia* spp., *Paracalanus parvus*, *Microcalanus pygmæus*, *Oithona* spp. and *Oncaea borealis* occurred in very great numbers, but were sparsely present at the same time in 1950. It was also apparent that these small copepods were in the very best condition ever seen in this area during these investigations. They were mostly of a bright red colour and all copepods were filled with oil.

Variations in the Volume of the Plankton

I have found it most convenient to give a fairly exact description of the variations of the plankton volume at st. A in the Hardangerfjord and later compare deviations of the other fjords in relation to this locality, as I did for the different species.

Fig. 2 shows the variation in plankton volumes in cc. at st. A in the Hardangerfjord from 24 February to 15 December 1950 in the hauls from 50—0 m., 100—0 m., 200—0 m. and 300—0 m.

In the 50—0 m. hauls the volume remained below 1. cc. until the middle of May. At the end of May and the beginning of June there was a very slight increase, (about 1,5 cc.) but again a decrease in the middle of June. At the beginning of July we get a sudden rise in the volume and the maximum of the year, 9,5 cc. occurred in the middle of the month. During August and September the volume decreased considerably, and was quite insignificant from October to December.

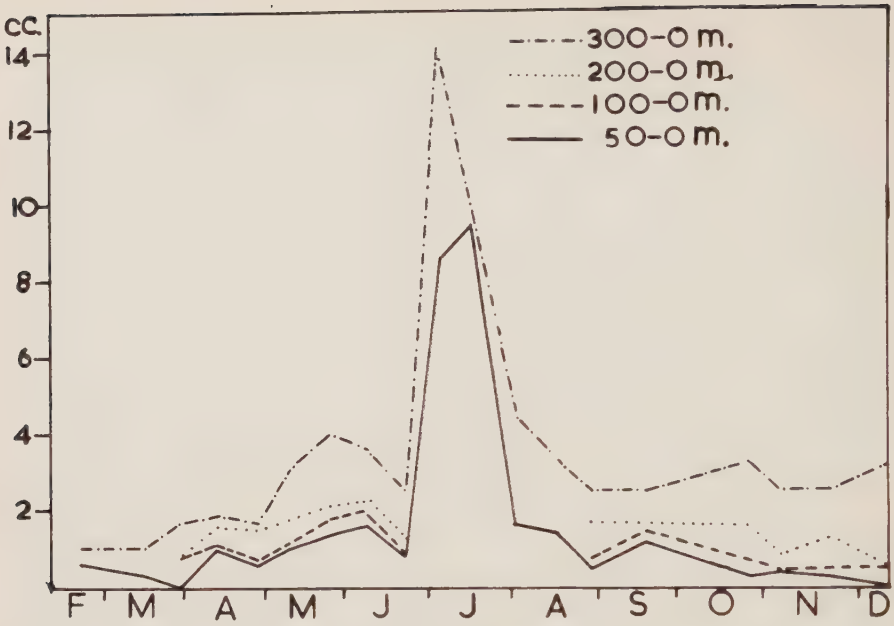

Figure 2. The variation of the volume of plankton in the vertical hauls at st. A in the Hardangerfjord during 1950.

It is apparent that the greatest variations takes place in the upper 50 m. layer. From the beginning of July to the beginning of August most of the plankton kept in these layers. The plankton volume per 50 m. of haul was only larger in the deeper layers at the beginning of April and from the middle of October to the middle of December. In the latter period the volumes were relatively larger in the water layer between the 200 m. and 300 m. levels.

In 1951, (fig. 3), the plankton volumes were also quite insignificant in the upper 50 m. from the end of January to the beginning of March. Some increase took place between 7 March and 11 April. Three weeks later the volume had decreased to 1,5 cc. and then remained constant to the last days of June. In the beginning of July the volume rose to more than 5 cc., the maximum of the year, but in the course of July the volume fell off rapidly to about 1 cc. in the middle of the month. At the beginning of September there was again a slight increase.

The water layers between 50—300 m. showed small variations, 1—3,5 cc. with maxima in the middle of June, and otherwise highest volumes in July—August.

The plankton volumes vary broadly in the same wayin 1950 and 1951. From the middle of April to the last part of June the volumes were generally a little higher in 1951, especially in the middle of April.

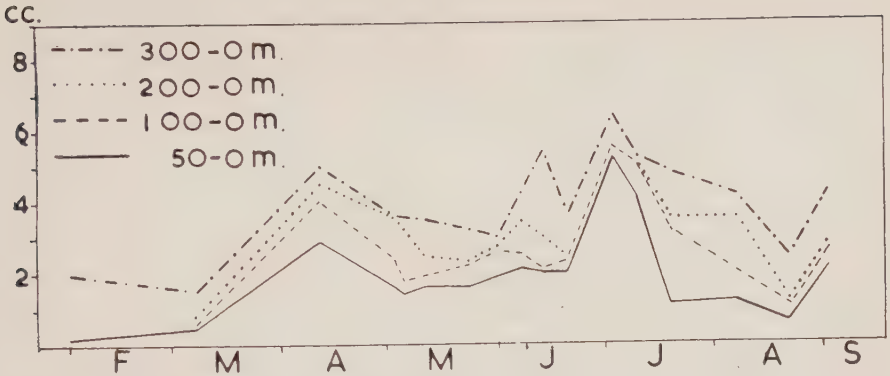

Figure 3. The variation of the volume of plankton in the vertical hauls at st. A in the Hardangerfjord during 1951.

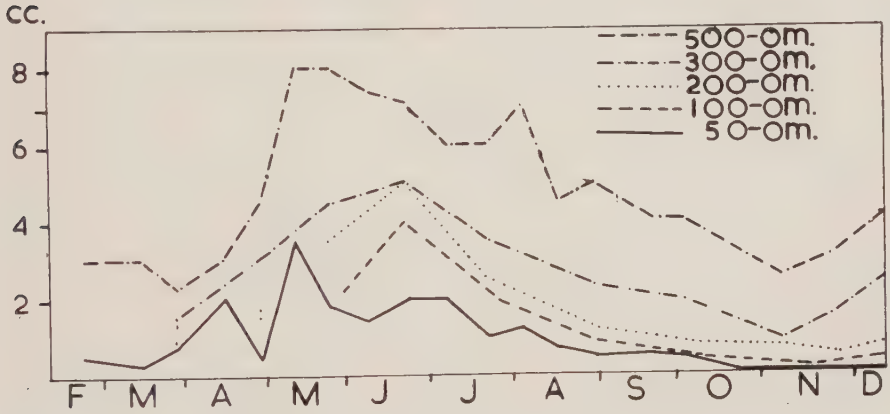

Figure 4. The variation of the volume of plankton in the vertical hauls at st. B in the Åkrefjord during 1950.

From the end of June to the beginning of August 1950 the volumes exceeded those of 1951 by 4 to 7 cc. From the beginning of August to September the quantities of plankton are for the most part similar both years.

In the middle of April the volume at st. B in the Åkrefjord (fig. 4) was twice as large as in the Hardangerfjord, and at the beginning of May three times as large but was considerably smaller in July. In the period 18 August — 24 November there were no special differences. In the course of June the deeper layers were a little richer, but later in the year were about the same as in the Hardangerfjord.

In the water layer from 300—500 m. the volume was quite small until the end of April, but increased to 3,5 cc. in the middle of May. Apart from some small variations the volume decreased to about 2 cc. in July and remained nearly constant until the beginning of October,

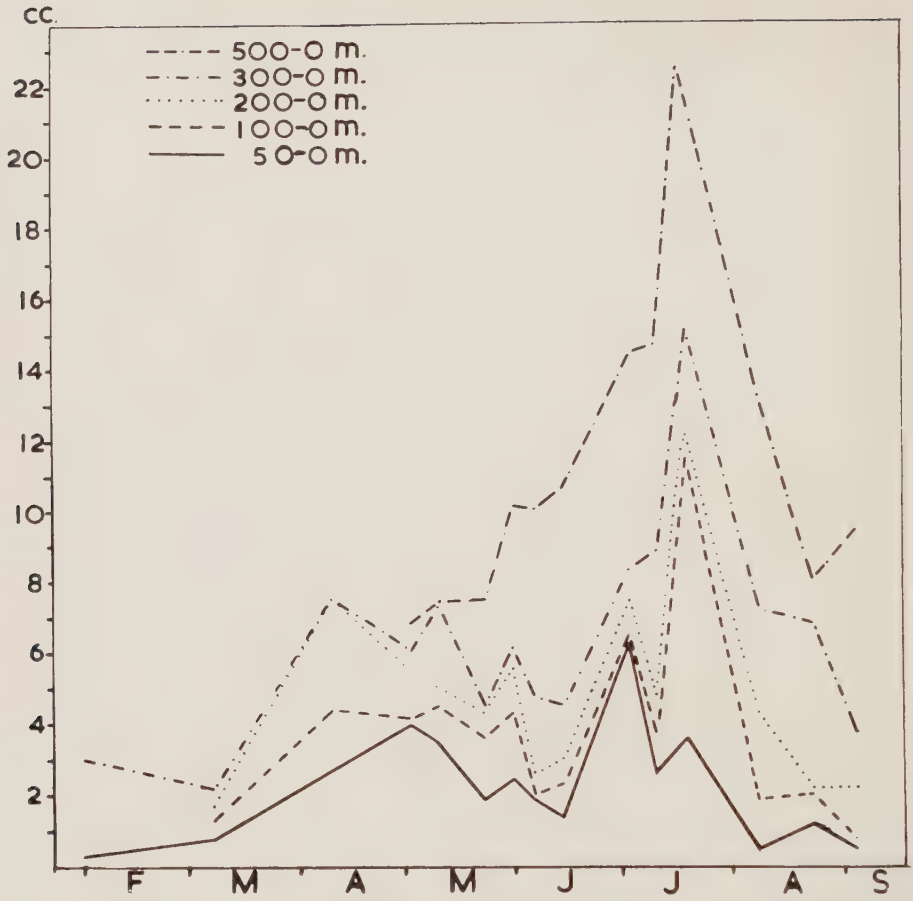

Figure 5. The variation of the volume of plankton in the vertical hauls at st. B in the Åkrefjord during 1951.

later in the year below 2 cc. We find seldom more than 1 cc. per. 50 m. of haul.

In 1951 (fig. 5) the plankton volumes were much greater than in 1950 in the upper 50 m. from the middle of July to the beginning of August, in the intermediate layers from the middle of June to the beginning of August, and in the deepest hauls from the beginning of June to the beginning of September. Compared with st. A the plankton volumes were greater at st. B most of the year 1951.

In the Skånevikfjord (fig. 6) there was a pronounced peak in volume in the upper 50 m. in the middle of May, in the deeper hauls at the end of May. In June the quantity of plankton decreased in all water layers, this was most pronounced in the upper 50 m. In July maximum for the year occurred as found at st. A, but again somewhat retarded in

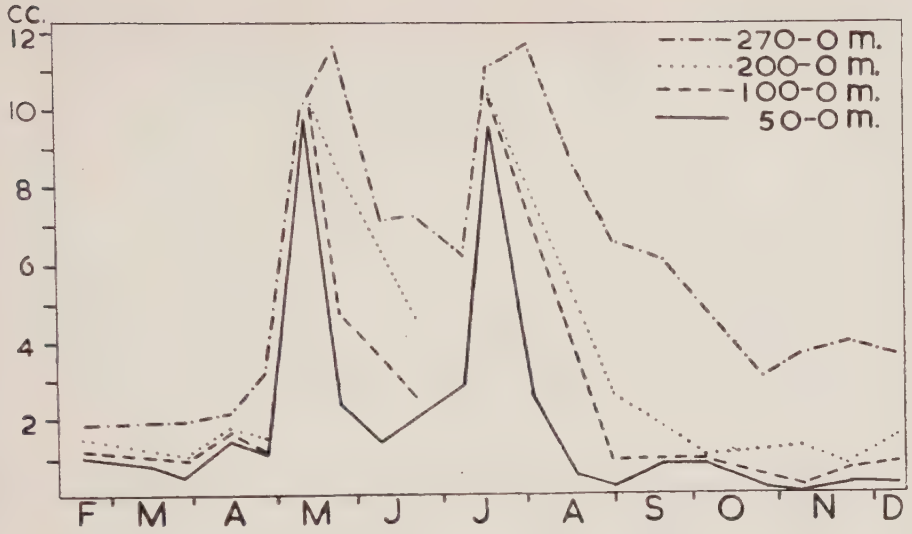

Figure 6. The variation of the volume of plankton in the vertical hauls at st. C in the Skåne vik fjord during 1950.

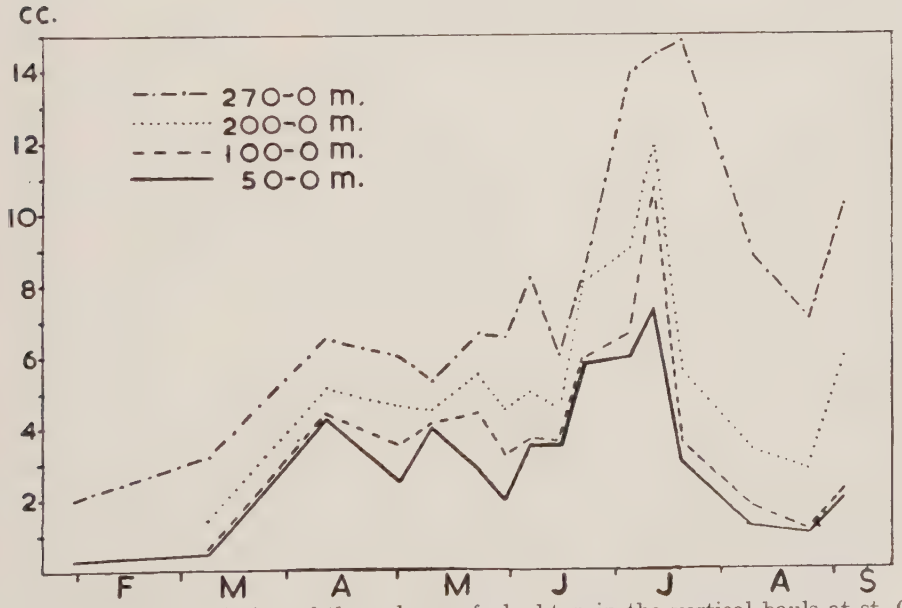

Figure 7. The variation of the volume of plankton in the vertical hauls at st. C in the Skånevikfjord during 1951.

the deeper layers. In the upper 50 m. the plankton volume went down to almost nothing in the middle of August. In the deeper layers the decrease was less pronounced, leaving a fairly high quantity of plankton (4 cc.) as a winter stock.

In 1951, (fig. 7) we find the same variation in the plankton.

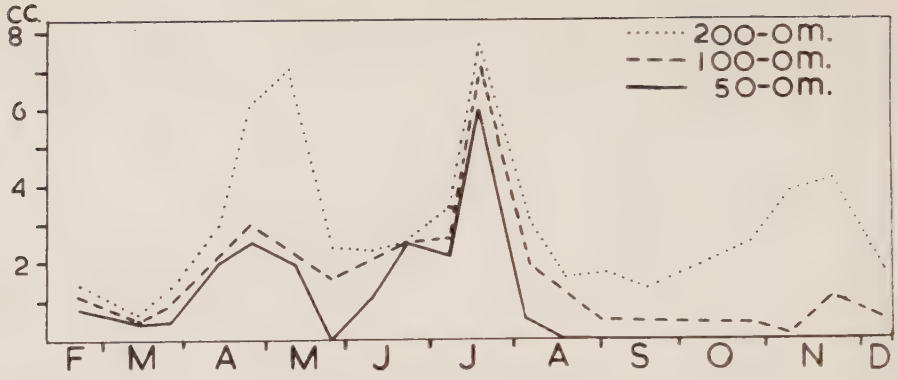

Figure 8. The variation of the volume of plankton in the vertical hauls at st. D in the Ålfjord during 1950.

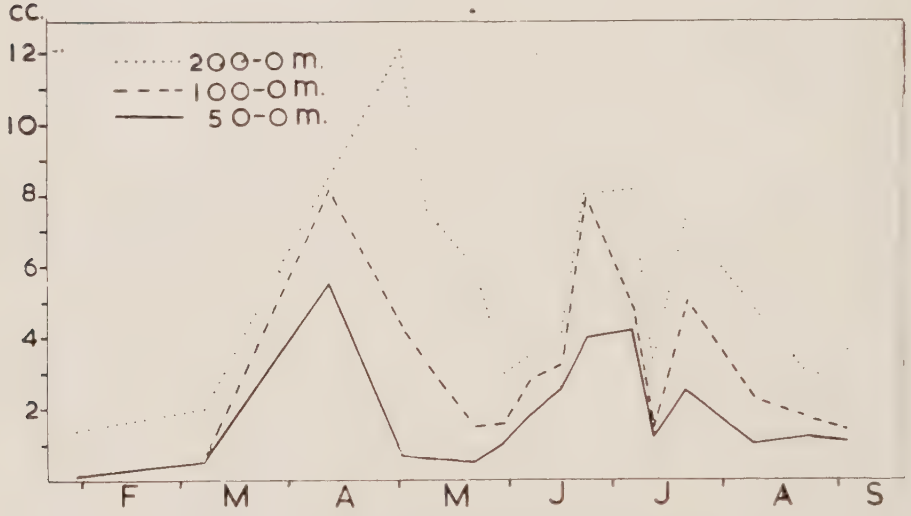

Figure 9. The variation of the volume of plankton in the vertical hauls at st. D in the Ålfjord during 1951.

The volumes were smaller from the end of April to the end of May than in the same period in 1950, but larger from the middle of June to the middle of July in the upper hauls, and from 15 June to 15 August in the deeper hauls.

The plankton volumes in the Skånevikfjord were on the whole above those at st. A, especially in the deeper hauls from July to September.

The volume variations in the Ålfjord (fig. 8) corresponded in the main features to those of the Skånevikfjord, but the quantities of plankton were on the whole smaller, and the May maximum in the upper 50 m. was second to the July maximum.

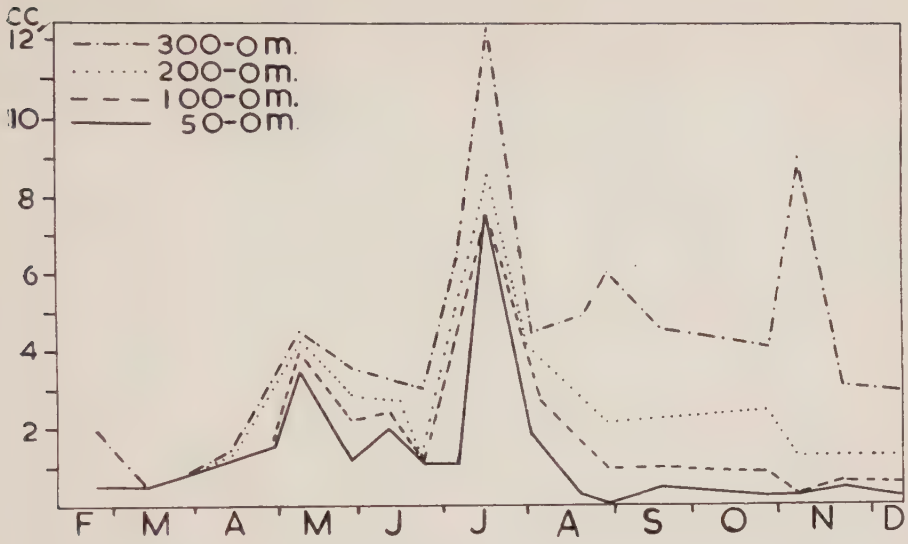

Figure 10. The variation of the volume of plankton in the vertical hauls at st. E in the Bjørnefjord during 1950.

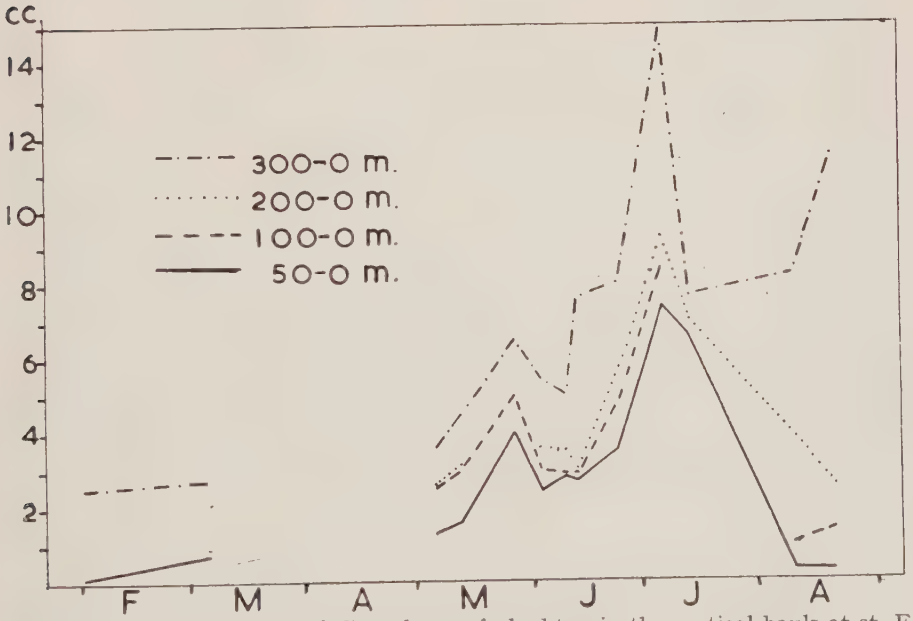

Figure 11. The variation of the volume of plankton in the vertical hauls at st. E in the Bjørnefjord during 1951.

In 1951 (fig. 9) the shape of the curves was mostly the same, but the two peaks both occurred about a fortnight earlier. In the upper 50 m. the first maximum was a little above, and the second a little below that of 1950. In the deeper hauls there were no special diver-

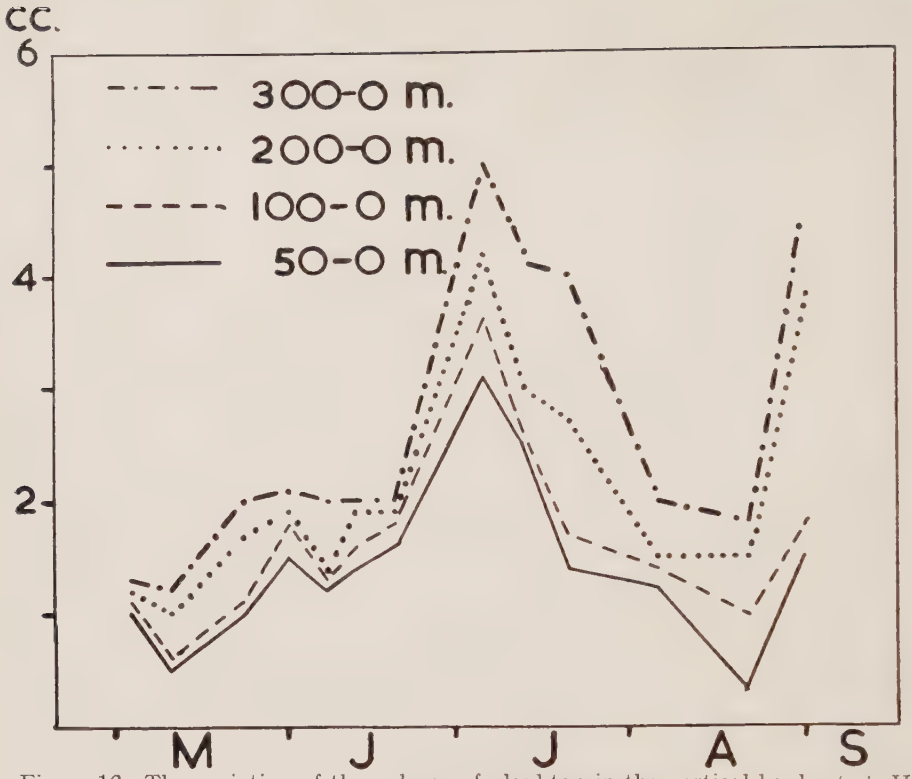

Figure 12. The variation of the volume of plankton in the vertical hauls at st. H in the Hardangerfjord during 1951.

gences, but on the whole the plankton volumes were larger in 1951.

Compared with st. A the plankton volumes were much larger in the upper 50 m. in the middle of April, and in the deeper hauls in May and from the middle of June to the end of July.

The variations of the plankton volume at st. E in the Bjornefjord (fig. 10) agree fairly well with the variations at st. A in the Hardangerfjord.

In 1951 (fig. 11) the plankton volume varied in the main as in the preceding year.

As mentioned above, plankton samples were taken regularly at the stations F, G in the outer and H, I in the inner Hardangerfjord from the beginning of May to September 1951. The variations in the plankton volumes at st. H, 30 kilometres further in than st. A are shown in fig. 12. In the upper 50 m. maximum in volume was found at the beginning of July, at the same time as at st. A but only half as large. Later the volumes were mostly equal at st. A and st. H. In the deeper hauls the figures were lower at st. H in the rest of the period investigated.

At st. I (fig. 13) the plankton volume were still smaller than at

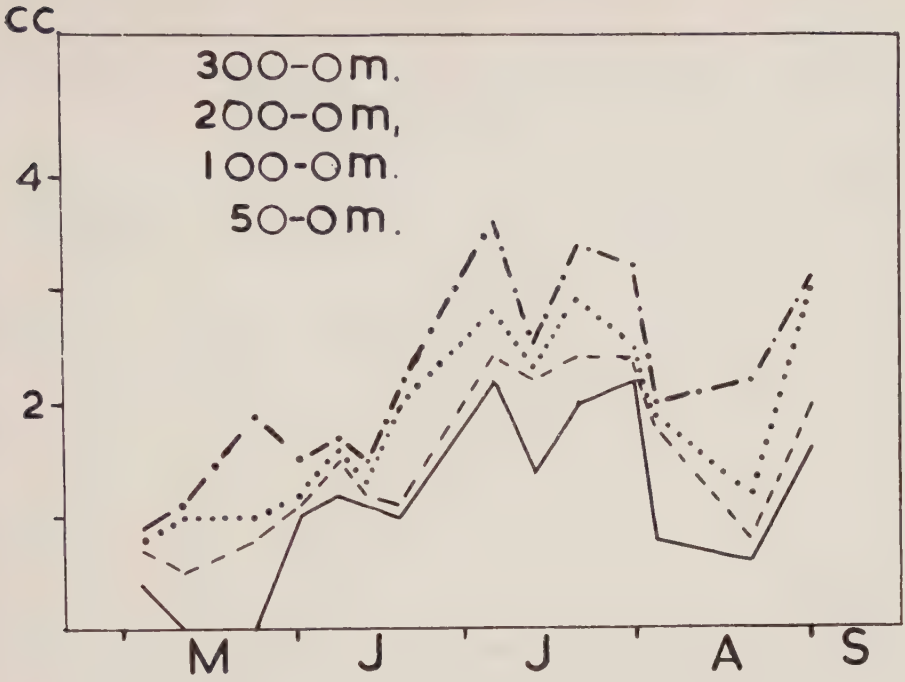

Figure 13. The variation of the volume of plankton in the vertical hauls at st. I in the Hardangerfjord during 1951.

st. A during all the period investigated. This station is situated about 50 kilometres away from st. A in the innermost part of the Hardangerfjord. During May the 50—0 m. hauls contained almost no plankton at all. In June the quantity increased a little but only reached a volume of 2 cc. at the beginning of July, and remained at this level during July. At the beginning of August the volume decreased, varying between 0,5 and 1,5 cc. during August and September. The water layers between 50—300 m. contained but little plankton all the time.

St. G is located in the outer Hardangerfjord, 15 kilometres further out than st. A. The variation of the plankton volume is shown in fig. 14. In the upper 50 m. the greatest volumes occurred in/or before the last part of May, at the beginning of July and in the last days of September or later. In the deeper hauls the summer maximum occurred after the middle of July. Throughout July the 100—0 m. hauls yielded nearly 5 times as much as the corresponding hauls at st. A, but otherwise the conditions were very similar in both localities.

Station F is located in the Bømmelfjord about 45 kilometres further out than st. A. The variations in plankton volumes are shown in fig. 15. In the upper 50 m. there were at least 4 pronounced peaks, before 1 May, at the end of May, beginning of July, and after 3 September.

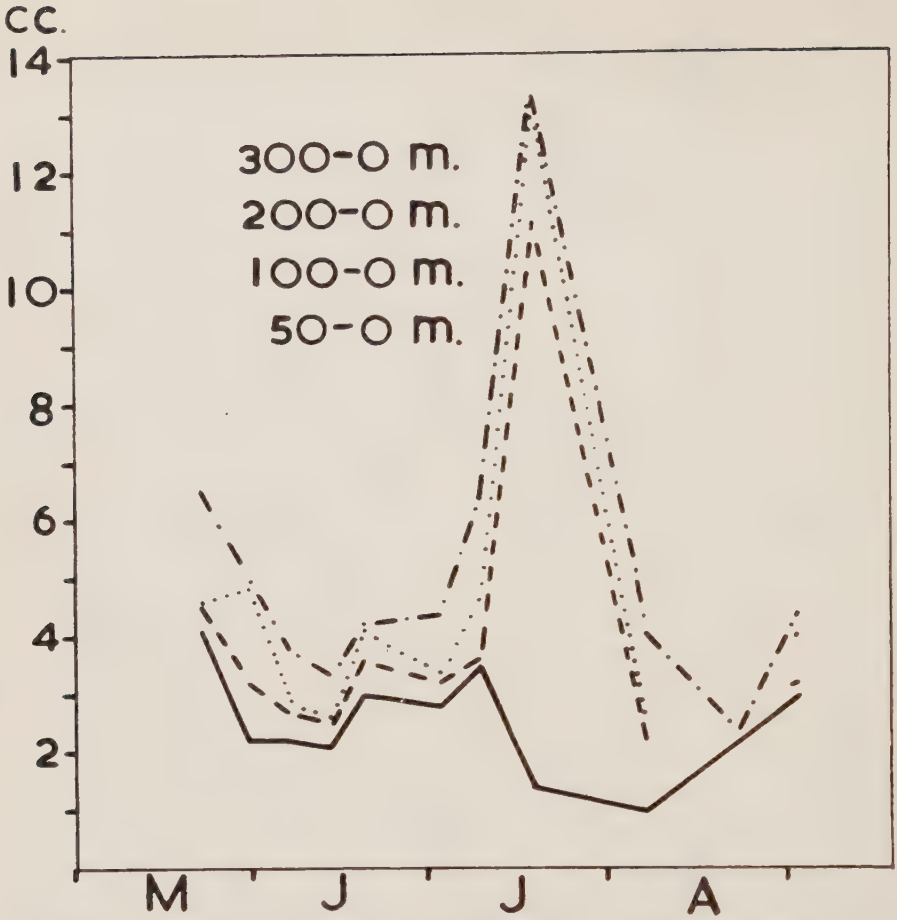

Figure 14. The variation of the volume of plankton in the vertical hauls at st. G in the Hardangerfjord during 1951.

In the deeper hauls there were great variations in the plankton volume from one date to another, especially in the water layers between 100 and 200m. from the end of May to the end of June. The intermediate water layers were on the whole very rich in plankton all the time. With some variations the volume increased from about 4 cc. at the beginning of May to about 18 cc. in the middle of July, the greatest quantity of plankton ever taken during these investigations, and the volume decreased but little till August, still measuring about 13 cc. at the beginning of September.

The five stations F, G, A, H and I are situated in a longitudinal section of the Hardangerfjord, the distances between them varying from 15 to 30 kilometres. Fig. 16 shows the average volumes of plankton during the period May—September in the vertical hauls from 50—0 m.,

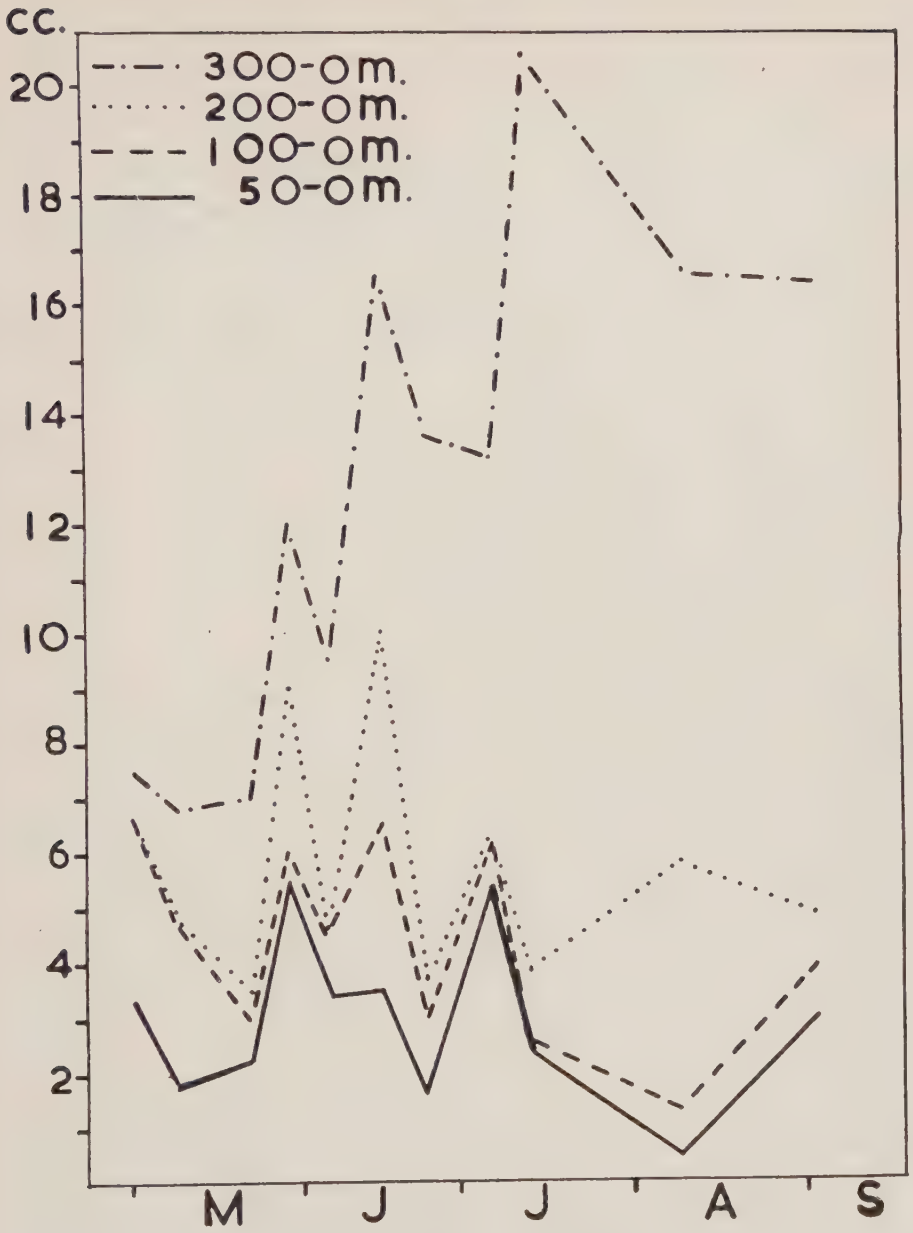

Figure 15. The variation of the volume of plankton in the vertical hauls at st. F in the Bømmelfjord during 1951.

100—0 m., 200—0 m. and 300—0 m. at each station. The volumes increased from the inner to the outer part of the fjord. In the inner part the differences in volume between the 300—0 m. and 50—0 m. hauls were but slight, but increased towards the outer part of the fjord.

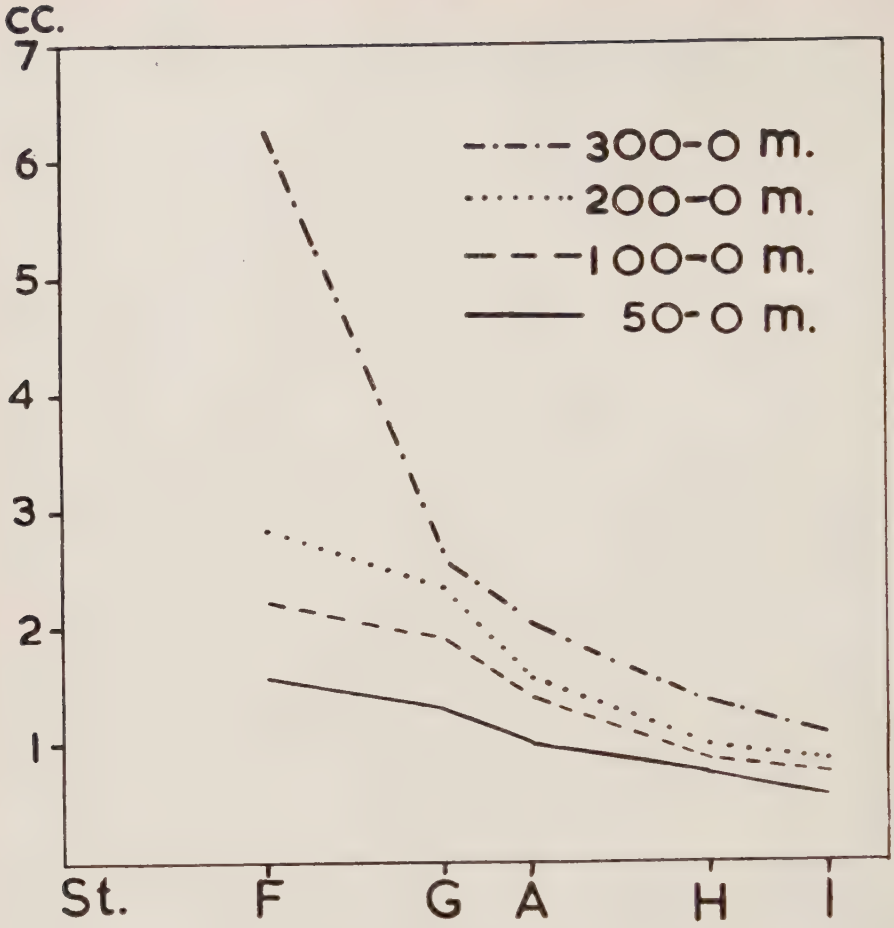

Figure 16. The average volumes of plankton at each station in the vertical hauls during the period May-September 1951.

The great differences in plankton volumes especially in the deeper hauls are probably caused by the composition of the plankton. In the upper 50 m. *Calanus finmarchicus* was much more numerous in the outer than in the inner fjord. In the deeper water layers the larger copepods *Pareuchaeta norvegica*, *Chiridius armatus* and *Calanus hyperboreus* were much more numerous at the outer stations F, G, and accordingly constituted a greater part of the plankton volume than at the inner stations H, I.

The Lusterfjord in Sogn, (fig. 17) was entirely different from the other fjords. In the upper 50—0 m. the plankton volume was quite insignificant from January to the beginning of April, when it increased a little and reached a maximum of only 1,5 cc. at the beginning of

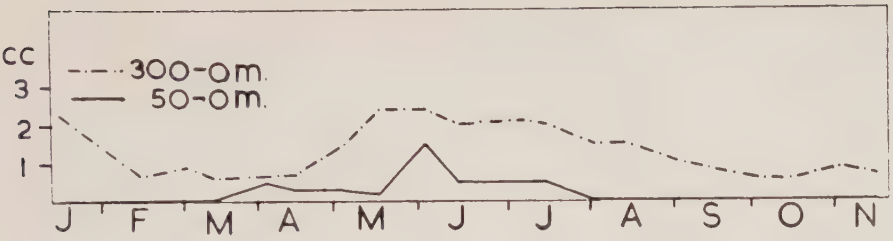

Figure 17. The variation of the volume of plankton in the vertical hauls in the Lusterfjord during 1950.

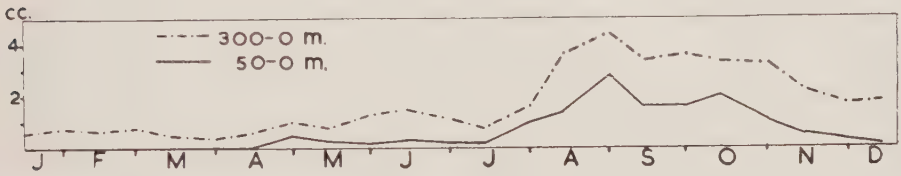

Figure 18. The variation of the volume of plankton in the vertical hauls in the Lusterfjord during 1951.

June. Later the volume again decreased to 0,5 cc. and kept at this level to the beginning of August, there after it was negligible.

In the layers between 50—300 m. thequantity of plankton measured a little more than 2 cc. on January 16, but decreased to below 1 cc. in the middle of February. From the middle of May to the middle of August the volume varied between 1 and 2 cc., and was for the remainder of the year below 1 cc.

In 1951 (fig. 18) variations were somewhat different. In the upper 50 m. the volume was quite insignificant during the first half of the year until the middle of July. At the beginning of August it began to increase, reaching a maximum volume of nearly 3 cc. at the beginning of September. Later in the autumn it decreased measuring between 1 and 2 cc. till the beginning of November. After that time the volume fell off gradually to almost nothing in the middle of December.

In the water layers between 50 m. and 300 m. the plankton volume had comparatively small variations during 1951, from January to August measuring 0,5—1 cc., the latter half of the year 1—2 cc.

The Hydrographic Conditions in the Investigated Areas

The hydrographic conditions in the area were investigated by Slaatsveen (1951). He concludes that an inflow of Baltic water of a salinity about 32 $^{0}/_{00}$ took place in the area in the period from 15 December 1950 to 31 January 1951. As the Baltic water had a higher

specific weight than the surface water in the fjords the inflow took place in the intermediate water layers.

Between January and 8 March the inflow of Baltic water continued but at this time at the surface. During these inflows no special differences have been observed in the composition of the plankton.

Influxes of Atlantic water in the deeper water layers were observed in 1950 in February—March and May—July, and in January—March and May—July of 1951. The Atlantic water cannot be seen to have brought in a plankton population of its own.

As mentioned before the greatest variation in volume and number of plankton took place in the upper 50 m. during July 1950 and 1951 in all localities. The stock of *Calanus finmarchicus* showed a steep increase in the number of individuals at the beginning of July 1950, stage IV of copepodites being most numerous. If the stock present at this time had originated from a propagation in the same area we should expect to find a higher numbers of nauplii and younger copepodites at an earlier date. The hauls in May and June were however very poor in *Calanus finmarchicus*. We may therefore assume that the sudden rise in number and volume of plankton at this time had been caused by an inflow of water in the upper or intermediate water layers from localities containing a large population of *Calanus*. The sudden occurrence of *Limacina retroversa* also points in the same direction. In July 1950 it was impossible to draw any conclusion from the hydrographic data regarding the movements of the surface water. We may nevertheless assume that an inflow had taken place, probably from neighbouring outer areas. Eggvin (1940) mentions that Baltic water penetrated into the fjords during June and July 1937 at a depth of 20—30 m. It is possible that an inflow of water from other localities occur fairly regularly every year, and the changes in the composition and quantity of the plankton during June—July 1950 and 1951 seem to support this assumption.

The hydrographic investigations showed that the water of the surface layers was higly stratified during summer and had great yearly fluctuations in temperature and salinity. Below 100 m. the temperature was nearly constant, varying between 7,5°—8° C. during the year.

Minimum temperature in the surface layers, about 2° C, occurred in March both years, but generally the temperature of the water was a little lower during the winter of 1951 than of 1950. The summer maximum occurred in August but was higher in 1950 than in 1951, 16° and 14° C. respectively, and at st. D in the Ålfjord the summer warming penetrated deeper down at an earlier time than at the st. s A, B and C. During May—July of both years the upper 50 m. were

highly stratified, the temperature decreasing from 16° C at the surface to about 8° C in 50 m. depth. As the vertical hauls were taken from 50—0 m. it is not possible to say to which extent this stratification influenced the vertical distribution of the plankton.

Variations in the Percentage of Fat- and Protein in the Plankton

Samples for estimation of fat and protein in dry-weight of plankton were taken from 50—0 m. every fortnight from the middle of May to the end of October 1950. Fig. 19 shows the results obtained at st. A in the Hardangerfjord. The variations of the volume of plankton are also given.

In the middle of May the percentage of fat was about 3, decreasing to 1,5 at the end of May. From the end of June the percentage increased sharply reaching a maximum of 16,5 in the middle of July. At the beginning of August it decreased to 3 %, rose a little in the middle of August, and attained about 6,6 % at the end of September. In October-November the fat percentage fell below 2.

The percentage of protein varied in the same way as the fat percentage, but with a greater range of variation. We note that the maxima in percentage of protein and of fat as a rule coincide with the maxima in volume of plankton.

At st. B in the Åkrefjord (fig. 20), the percentage of fat was considerable lower than at st. A in the Hardangerfjord during the whole

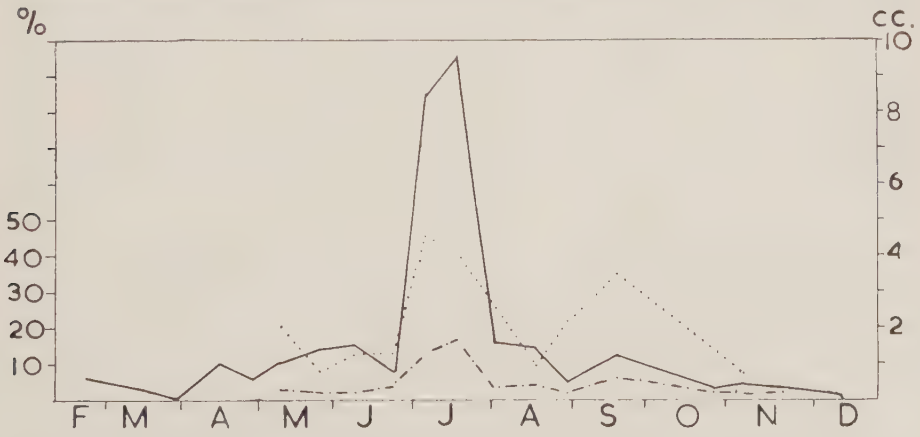

Figure 19. Plankton samples in vertical hauls from 50—0 m at st. A during 1950.
———— Volume of plankton in cc. Right-hand scale.
—·—·—· Percentage of fat in dry-weight of plankton. } Left-hand
..... Percentage of protein in dry-weight of plankton } scale.

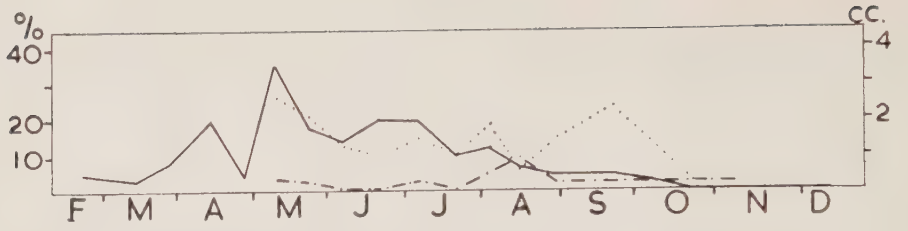

Figure 20. Plankton samples in vertical hauls from 50—0 m at st. B during 1950.
———— Volume of plankton in cc. Right-hand scale.
·—·—· Percentage of fat in dry-weight of plankton. } Left-hand
..... Percentage of protein in dry-weight of plankton. } scale.

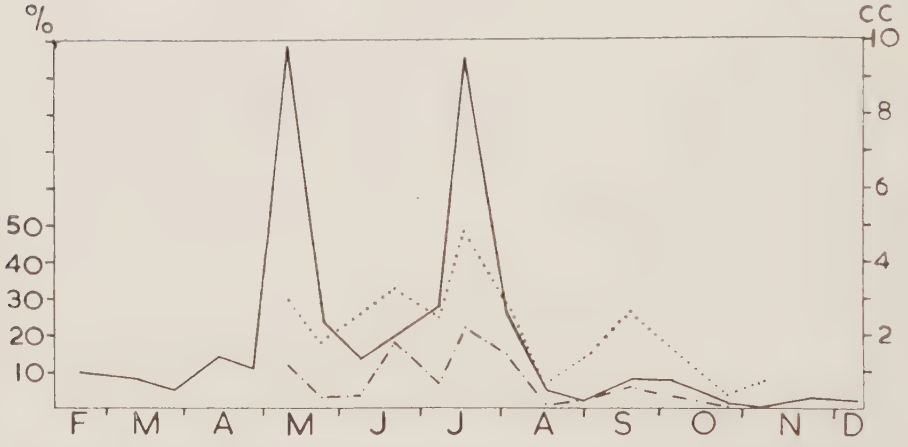

Figure 21. Plankton samples in vertical hauls from 50—0 mat st. C during 1950.
———— Volume of plankton in cc. Right-hand scale.
·—·—· Percentage of fat in dry-weight of plankton. } Left-hand
..... Percentage of protein in dry-weight of plankton. } scale.

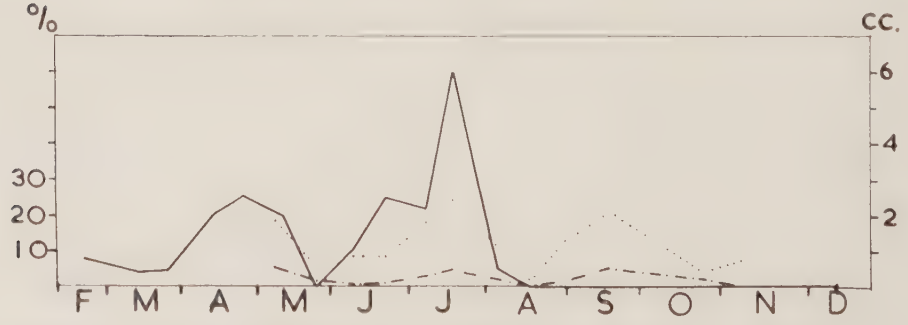

Figure 22. Plankton samples in vertical hauls from 50—0m. at st. D during 1950.
———— Volume in cc. Right-hand scale.
· · · Percentages of fat in dry-weight of plankton. } Left-hand
..... Percentage of protein in dry-weight of plankton. } scale.

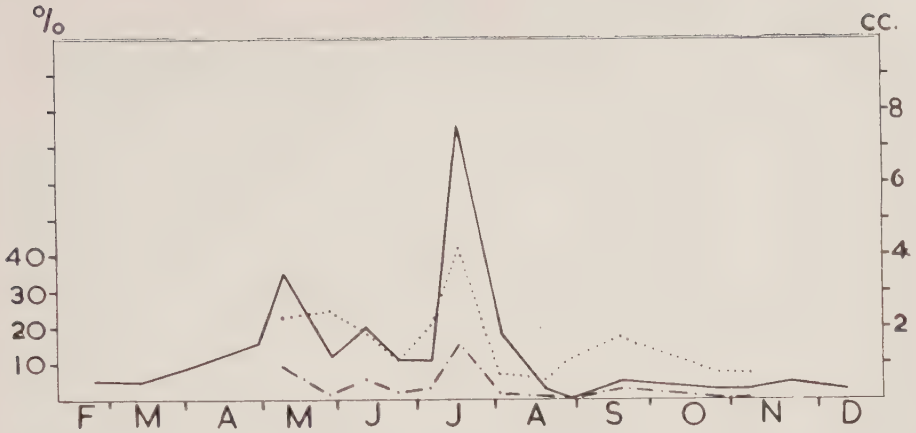

Figure 23. Plankton samples in vertical hauls from 50—0 m. at st. E during 1950.
———— Volume of plankton in cc. Right-hand scale.
—·—·— Percentage of fat in dry-weight of plankton. } Left-hand
..... Percentage of protein in dry-weight of plankton. } scale.

period investigated, and no increase took place in the middle of July. Maximum in fat, 9,17 % occurred in the middle of August. The percentage of protein was also below that of st. A all the time, with peaks in May, July and September.

The variations in the percentage of protein and the volume of plankton showed a rather good agreement in the first half of the period investigated, but was later more irregular.

At st. C in the Skånevikfjord (fig. 21) the percentage of fat was above 11 in the middle of May, and more than 17 in the last part of June. From the beginning of July to December the fat percentage mostly maintained the same level as in the other fjords. The percentage of protein varied nearly parallel to the fat percentage.

At st. D in the Ålfjord (fig. 22) we find the highest percentage of fat in the middle of May, otherwise the curves have a similar course as in the Hardangerfjord, but the figures were always lower, especially in July.

The percentage of protein was generally not so high as in the Hardangerfjord, but the variations were similar to those of the other fjords. Maximum percentage occured in the middle of July.

At st. E, in the Bjørnefjord (fig. 23) the fat percentage was rather high in May—June, otherwise the values do not deviate much from those in the Hardangerfjord. This was also the case with the percentage of protein.

With some exceptions the fjords in the Hardanger area are fairly comparable with regard to the volume of plankton, total number of organisms and percentage of fat and protein. To get a general view

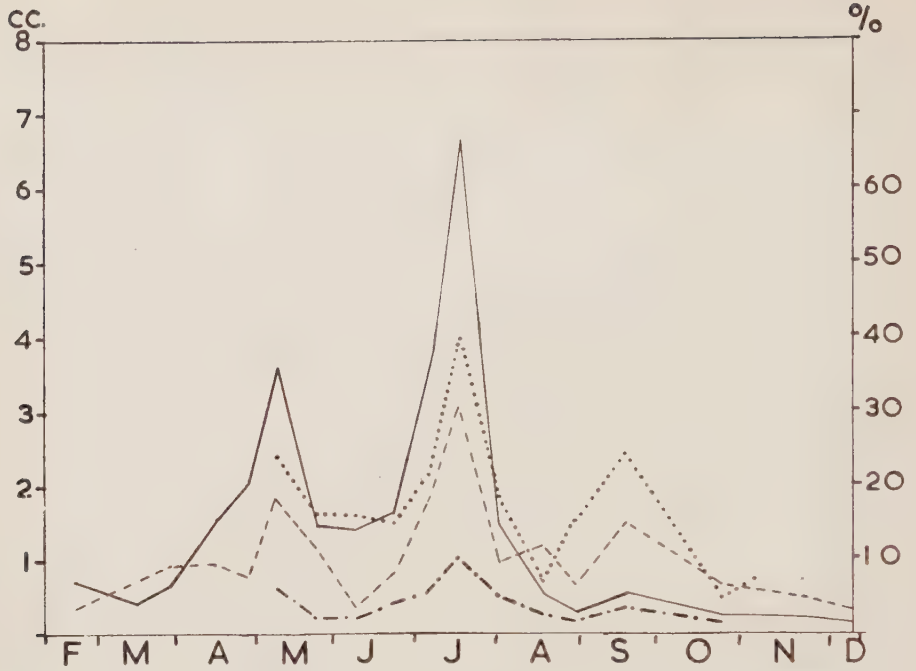

Figure 24. Plankton samples in vertical hauls from 50—0 m. at the stations A-E during 1950.

———— Average volume of plankton in cc. } Left-hand
— — — Average number of organisms in 10 000. } scale.
—•—•—• Average percentage of fat in dry-weight of plankton. } Right-hand
..... Average percentage of protein in dry-weight of plankton. } scale.

for the whole area I have calculated the average figures for the 50—0 m. hauls at the st. s A-E during 1950, (fig. 24).

The average volume of plankton is below 1 cc. from February to the beginning of April. Thereafter it increases comparatively slowly to 4 cc. at the beginning of May. In the course of May there is some decrease, and there is a volume of about 2 cc. in most of June. At the beginning of July the volume rises sharply to the maximum of the year, about 7. cc. From the middle of July it decreases steadily reaching an insignificant value at the end of August and remaining low after this.

The average number of organisms has a similar variation with peaks in the middle of May and the middle of July. In addition there is also a peak in the last part of September. The smaller copepods, *Acartia* spp., *Pseudocalanus minutus*, *Oithona* spp. and others dominated the samples entirely in September, the volume of plankton increasing but slightly.

The percentage of fat shows three peaks, one at the beginning of

May, the second and highest peak in the middle of July, and the third in the middle of September.

The protein percentage shows in the main the same variations the figures always being higher than those of the fat.

It is evident that the highest percentages of fat and protein are found simultaneously with the maxima in the total number of organisms and the volume of plankton. There is apparently a close relation between the food conditions for the plankton and the rate of propagation. This has clearly been shown by MARSHALL (1950) for *Calanus finmarchicus*.

The greatest variations in the plankton usually take place in the upper 50 m. layer, especially in spring and summer. In the autumn the greater part of the plankton is found in the water layers below 50 m.

The samples for determination of fat and protein were taken from the 50—0 m. hauls most of the time. But at the end of November the upper layers were so poor in plankton that it was impossible to get sufficient material. For that reason samples for analysis were taken from the deeper hauls in November and December.

The results of the analysis were as follows:

	24/11—50		15/12—50	
	Fat %	Protein %	Fat %	Protein %
Hardangerfjord 300—0 m.	10,3	19,6	5,4	8,8
Bjørnefjord 300—0 m.	31,5	42,8	5,1	7,0
Skånevikfjord 270—0 m. ..	21,8	33,4	4,7	8,7
Åkrefjord 300—0 m.	6,1	10,6	1,4	2,9
Ålfjord 200—0 m.	19,3	35,6	—	—

Apart from the Åkrefjord the plankton in all the fjords held a very high percentage of fat and protein in the last part of November, for some of the stations even higher than ever found in the hauls from 50—0 m. We may therefore assume that the plankton in the deeper water layers will contain a greater percentage of fat and protein at other seasons also.

In the middle of December the content of fat and protein in the plankton had decreased considerably in all the fjords, but in some localities there was a small increase in number of organisms and volume of plankton . It is therefore apparent that the plankton organisms at this time of the year are consuming their reserves of fat and protein.

The investigations have shown that in the course of the year two peaks occur both regarding plankton volume and number of organisms.

The size of the figures varies a little from one year to another, as do also the exact dates of the occurring maxima and minima. One has to expect that such variations will be found from year to year.

Comparison with Other Observations

NORDGAARD (1901, 1910) held the opinion that *Calanus finmarchicus* reached its maximum in number in the coastal waters on the west coast of Norway in May and June. But in the Korsfjord south of Bergen he also found a great quantity of plankton in the upper 100 m. layers in September 1899. In July 1900 he observed an abundance of zooplankton in the Herløfjord north of Bergen.

Off Møre RUUD (1929) and WIBORG (in press) found a peak in volume of plankton in April—May, and in July and maximum in the number of copepods occurred at the same time. The increase in volumes coincided with the mass development of *Calanus finmarchicus*.

At Sognesjøen, a little further south on the west-coast of Norway, WIBORG in 1949—51 found the highest values in plankton volume at the beginning of April and in the middle of June.

In his paper on the zooplankton of the Herdla— and the Hjeltefjords RUNNSTROM (1932) remarks that older copepodites (stage IV—V) of *Calanus finmarchicus* occurred numerously throughout the year but not in equal proportions in the different depths. During the winter these stages were found only sparsely in the upper 100 m., in March they increased in number and were most abundant from April to September.

P. BJERKAN has a number of observations on the occurrence of zooplankton in the fjords south of Bergen. But his conclusions were founded on subjective estimates without any data on number or volume. (BJERKAN 1939, 1940, 42, 44). In 1938 the plankton was abundant in the fjords in Hardanger, Sunnhordland and in Ryfylke about 12—23 May, especially in the outer districts. At this time the stomachs of the sprat were filled with «rauåte» (*Calanus finmarchicus*) in such quantities as had rarely been observed before. In 1939 plankton was scarce in the last days of May in an area from the Sognefjord in the north to the Ryfylkefjords in the south, especially in the inner part of the fjords. In July of the same year great changes were observed, the plankton at most places being very rich. The changes were presumed to have some connection with the hydrographical conditions as an inflow of warmer water took place in all areas at a somewhat earlier date in the southern fjords than further north.

On account of the fine quality of the sprat at the end of May in the year 1940, BJERKAN was of the opinion that the quality of the plankton had been very good early in the spring. At the end of August the plankton was more abundant in the inner parts of the fjords than in the years before. *Calanus finmarchicus* was sparsely present, but the smaller copepods were very numerous.

In 1941 the copepod plankton was very poor 8—22 May 1941, and the development of the phytoplankton retarded. Plankton remained scarce during the first part of the summer, especially in the inner part of the fjords. In the last part of July the number of organisms increased, but *Calanus finmarchicus* occurred only spasmodically.

In April—May 1942 the conditions were very similar to those in the same period of 1941.

In adjacent areas of the North Sea, RAE and REES (1947) found copepods to be most numerous in 1938 in May—June and July, with maximum in May, in 1939 with maximum in June. For *Calanus finmarchicus* REES (1949) found maximum in 1938 in May and in 1939 in April—May. The investigations were based on samples from 10 m. depth, with Hardy's continuous plankton recorder.

NORDGAARD and RUNNSTRØM have no figures of the number of organisms and the volumes of plankton, but both authors give the time from April to August as the main period for the production of plankton. The other investigators mentioned all indicate two peaks in the volume of plankton and total number of organisms, one in March—May, and another in June—July. In the open waters we always find the highest peak in the first period, in the skerries the second peak is the highest one.

In all localities almost the same species of plankton organisms occur, and there is a very good agreement of the mass development of *Calanus finmarchicus* and the peaks in the plankton volumes.

Determinations of the fat content in plankton were first made by BRANDT (1898), later by BRANDT and RABEN (1919—22) and WIMPENNY (1929, 1938). Determinations of the fat content in *Calanus finmarchicus* and *Euchaeta norvegica* were carried out by ORR (1934) and MARSHALL, NICHOLLS and ORR (1934).

ORR (1934) found the percentage of fat in *Calanus finmarchicus* to be considerably higher than previously recorded from mixed catches of zooplankton, but the protein content was, on the other hand, lower. The highest content of fat in stage V of *Calanus finmarchicus* approx. 46 %, was observed in Loch Fyne in March, and minimum approx. 20 % in May. From the last part of July to October the fat content varied from 35 % to 40 %.

In Loch Striven Marshall, Nicholls and Orr (1934) found the highest fat percentage of *Calanus finmarchicus* in April and June.

In the localities investigated the greatest percentage of fat in the plankton occurred at the same time as the maximum stock of *Calanus finmarchicus*, and there was a marked decrease when *C. f.* left the upper water layers.

Wimpenny (1929) made fat determinations of the zooplankton from different depths and found a higher fat content in the plankton near the bottom than at the other depths.

In the present investigation plankton samples from the upper 50—0 m. have mainly been used for the determination of fat and protein. In the late autumn a few samples from greater depths were analysed, and the fat content was very high compared with that found in samples from the upper 50 m. It is therefore possible that a determination of fat and protein in samples from deeper hauls in the Hardanger area would on the average, give higher values all the year than from the 50-0 m. hauls and the range of variation from maximum to minimum would probably also be smaller. Wimpenny (1938) records the mean monthly percentage of fat as varying between 12,6 and 18,4 % from May to December, while in the Hardanger area the fat content varied between 1,1 and 11,8 % in the same period. Wimpenny gives no data for the depths of the hauls but they were probably taken from bottom to surface. Maximum percentage of fat was observed in July, which is in accordance with the results obtained in the present investigation.

Summary

At the end of February 1950 investigations on zooplankton were initiated in some fjords south of Bergen on the west coast of Norway, and continued during 1951. Simultaneously hydrographic observations were also taken.

Of all copepods occurring *Calanus finmarchicus* was the most important. The highest numbers were observed in 1950 in May and July, and in 1951 in April and July. When the maxima of *Calanus finmarchicus* occurred the greater part of the stock was found in the upper 50 m. water layers. Spawning took place in Februar—March, May—June and in September, the most important one in May—June.

Pseudocalanus minutus was, next to *Calanus finmarchicus*, the most important species in the upper 50 m. Maximum number occurred in July both years.

Temora longicornis was found to be most numerous in July and *Acartia clausi* in July and September.

The larger copepods *Pareuchaeta norvegica, Calanus hyperboreus,, Metridia longa, M. lucens* and *Chiridius armatus* were found sparsely in the upper water layers. In the deeper hauls they were more numerous and because of their size made up a greater part of the volume, this was especially the case in the outer districts.

Of other organisms *Limacina retorversa* was very abundant in July 1950 but sparsely present during 1951.

The highest total number of organisms occurred in May, July and September 1950.

The largest volume of plankton were found in May and July 1950 and in April and July 1951.

A longitudinal section of the Hardangerfjord showed great differences from the inner to the outer part of the fjord, the volume of plankton being much higher in the outer part, especially in the deeper hauls.

The Lusterfjord in Sogn was entirely different from the fjords in the Hardanger area. The total number of organisms and the volume of plankton were much smaller here.

The greatest percentage of fat was found in May and July, and of protein in May, July and September in the upper 50 m. during 1950. The deeper hauls showed a great percentage of fat and protein in the late autumn.

The maximum in volume of plankton and the highest percentage of fat coincided with the maximum in number of *Calanus finmarchicus*.

A comparison is made with previous work in this and other areas.

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